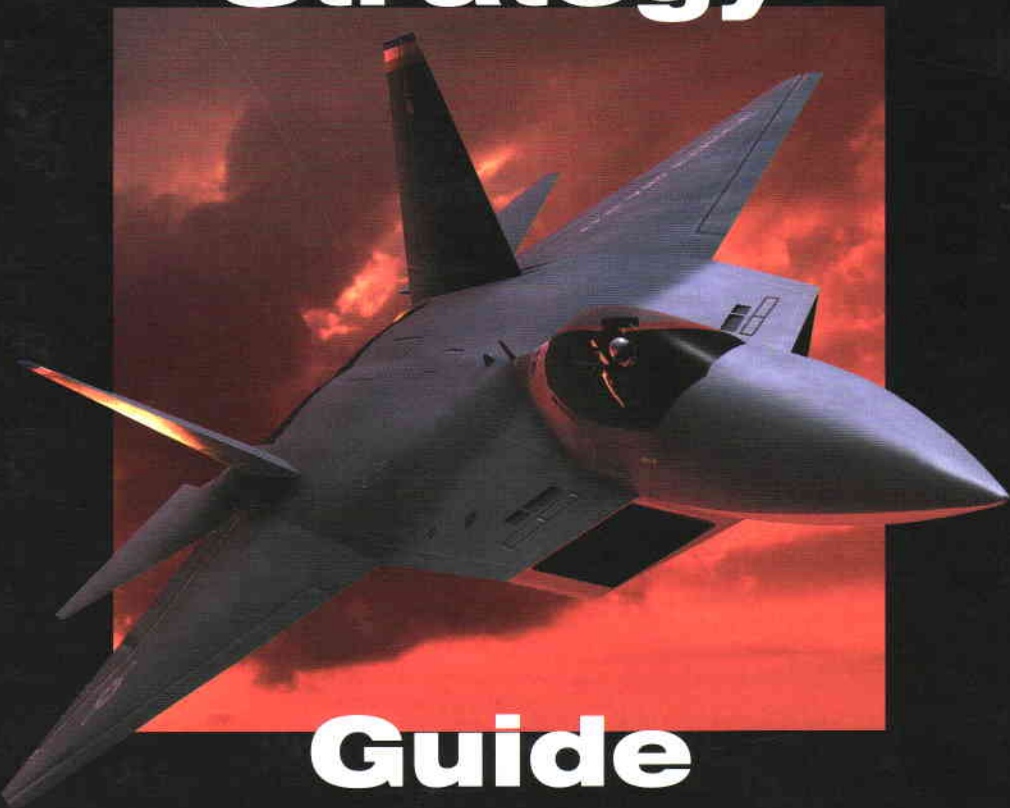
THE OFFICIAL

F22

DID AIR DOMINANCE FIGHTER

Strategy



Guide

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SIM TECH

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Contents

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Chapter 1

INTRODUCTION

CHAPTER 1

Introduction

'In its guide to EF2000 by Digital Image Design, Sim Tech produced the most comprehensive player's guide ever written for a combat flight simulation. This new guide to F-22 Air Dominance Fighter and Total Air War hits the target again, revealing in words and pictures the depth of gameplay that DID has striven to achieve in each new simulation. The authors of this guide have been as thorough as ever in exploring and expanding upon the many new features we introduced in our successors to EF2000; for example, the AWACS and the War Room, with their profound impact on the quality of tactical gameplay; the Custom Combat module, which offers unique ways to learn the art of modern air combat; and of course the F-22 itself, with its thrust-vectoring, stealth and advanced weapons systems. In creating its own mission disk - Red Sea Operations - Sim Tech also became uniquely qualified to write about the inner workings of DID's latest simulations.

I would urge anyone who owns F-22 Air Dominance Fighter, Red Sea Operations and Total Air War to explore the chapters of this book thoroughly, and learn the hints and tips it describes in such detail. Not only will you enjoy hours of entertaining discovery, you will hone your skills in ways that real fighter pilots and commanders would approve (both the Royal Air Force and USAF have expressed interest in using F-22 ADF and TAW as teaching aids).

A guide of this magnitude is the greatest testimony that any developer could wish for. I am sure it will increase your enjoyment of F-22 ADF, Red Sea Operations and TAW many times over.'

Don Whiteford, Development Director, DID Ltd.

In the year since its original release, F-22 ADF has, in the tradition of DID's products, been the subject of continual development and improvement. As of November 1998 this process included a maintenance patch to F-22 ADF, the Sim Tech add-on tours (Red Sea Operations) and Total Air War (with further enhancements in the latest free TAW patch). This book covers all these developments.

The result of many thousands of hours of play testing and research, The Official F-22 ADF Strategy Guide is a complete resource for players of F-22. Since all the writers are flight simulation fanatics you can be sure that the tips, strategies and tactics are truly 'combat proven' and not simply posturing or fancy rhetoric. Whilst many of the suggestions and techniques included in this book can be applied successfully in other simulations the reader should be certain of one unmistakable fact; like The Official EF2000 Strategy Guide, this book is about the F-22 ADF/TAW simulation and though the level of technical information and analysis is way beyond that seen in more 'traditional' strategy guides, you should not confuse it with real world application. This book is about how the simulated F-22 behaves in the simulation, not in the real world. The strategies and tactics are specific to this simulation and should not be confused with real world techniques. That said, since F-22 ADF/TAW is a realistic simulation there are numerous crossovers and accurate comparisons to the real world can be made.

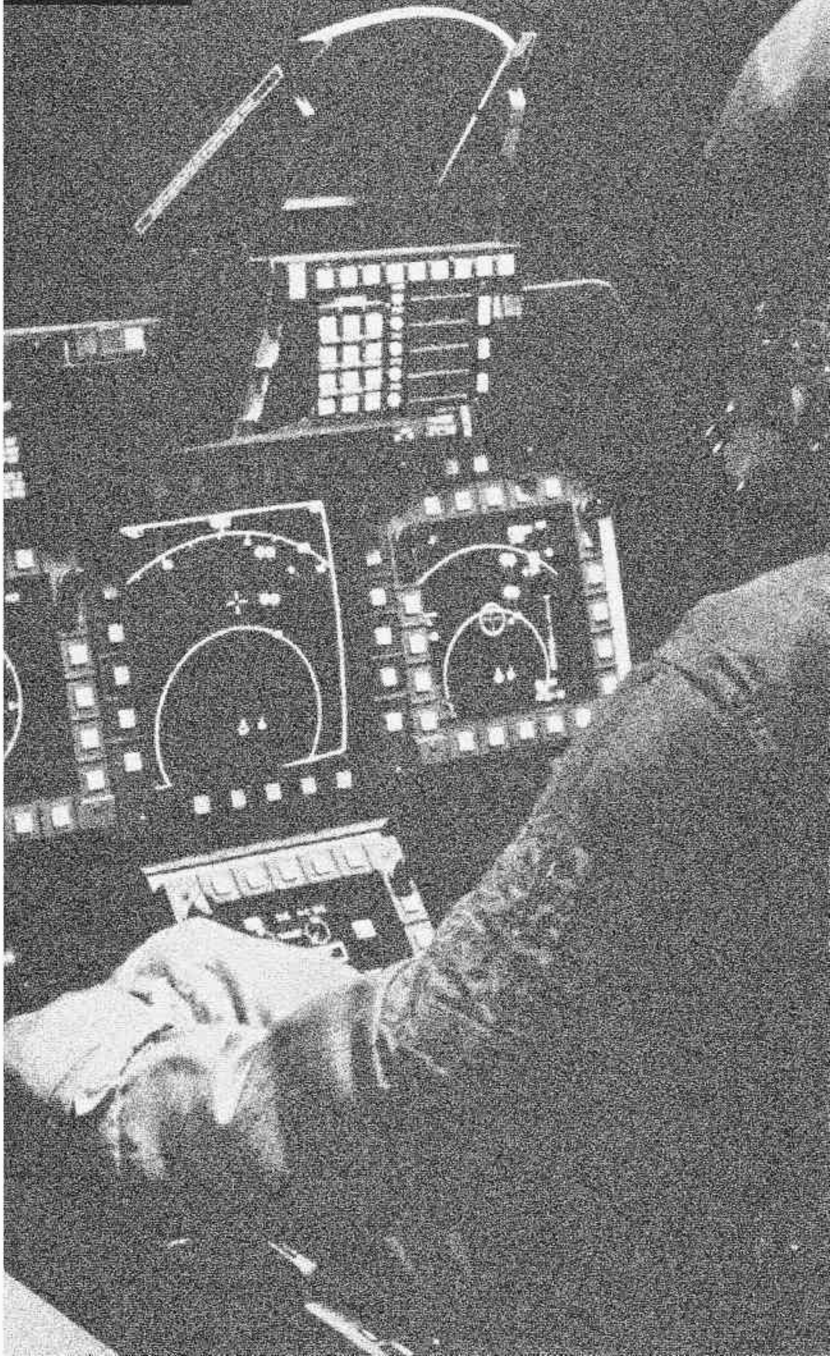
Naturally, this book is a step beyond the F-22 ADF/TAW manuals and hence we expect you to have a working knowledge of the simulation, its features and systems. From that point onwards, this book will help further your understanding of the simulation, whether you are a relative novice or consider yourself amongst the elite of flight simulation players, every aspect of this book will expand your ability and understanding of F-22 ADF/TAW.

We sincerely believe that The Official F-22 ADF Strategy Guide continues in the vein of The Official EF2000 Strategy Guide - regarded by Computer Gaming World's Denny Atkin as; "one of the best simulation strategy guides I've ever seen" - and that the considered suggestions and advice contained herein will help you maximise your enjoyment and effectiveness in Digital Image Design's F-22 ADF/TAW.

Dominic Silk

Chapter

2



AVIONICS

RADAR AND SENSORS

TSD

ATTACK MFD

DEFENCE MFD

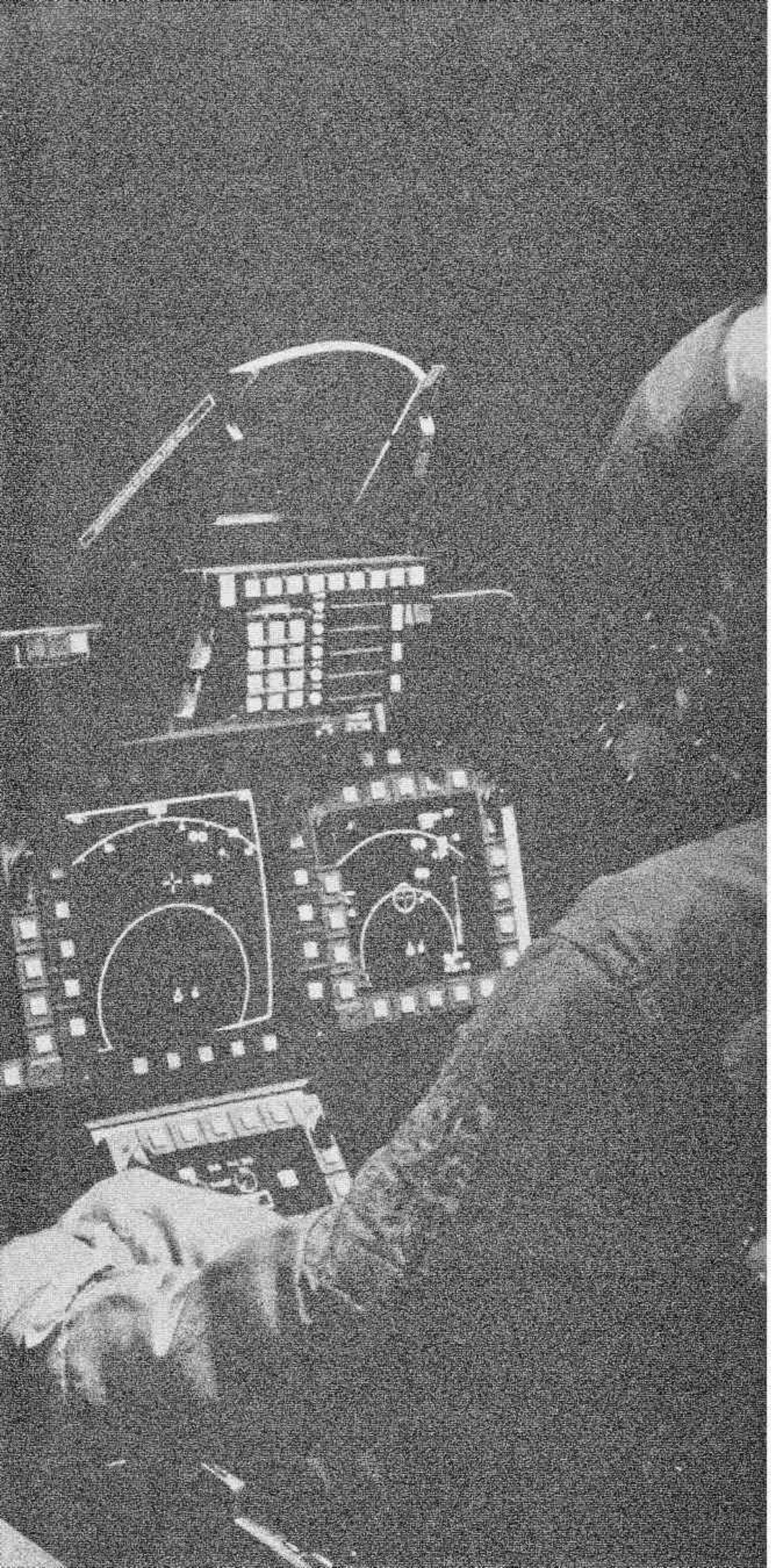
SYSTEMS MFD

SUPPLEMENTARY MFDs

USING SHOOT LISTS

HEADS UP DISPLAY

AUTOPILOT



CHAPTER 2

Chapter 2

Avionics

Knights of the skies. The term has often been used to characterize the pilots who fly air combat missions. Unlike their medieval counterparts however, today's pilots aren't relying on their steeds solely for speed and agility. Today's modern 'chargers' must take a much more active role in pursuing the goals of warfare - defeating the enemy. The ideal of modern air combat is to arrive, undetected, at a location that allows you to dispatch the enemy from the greatest possible distance, thereby minimizing risk to aircraft and pilot. Increasingly, information management and stealth tactics are necessary to complete this task successfully.

Arguably the most advanced multi-role fighter ever designed, the F-22 provides its pilot with unparalleled access to up-to-the-minute tactical and strategic information. Coupled with the F-22's stealthy design, this aircraft truly fulfills its role as an Air Dominance Fighter.

Key to the F-22's advanced avionics systems is the high degree of integration between the various components. Common Integrated Processors (CIPs) direct and coordinate most avionics functions such as mission management, sensor control and tasking, target tracking, weapons fire control, defence, navigation, flight stability and systems diagnostics. Nearly three dozen computers in each of two CIPs run the software - about 1.6 million lines of code - for these capabilities.

Traditionally, many, if not most, of these functions were handled by separate systems, forcing the pilot to operate individual sets of controls and displays for each one. By combining these functions into one, integrated architecture, the F-22's avionics identify the most critical information you need and delivers it via synthesized controls and Multi-Function Displays (MFDs).

The F-22 features a full 'glass' cockpit where flight instrumentation is presented through a total of seven different MFDs as well as the Heads Up Display (HUD) and Helmet Mounted Display (HMD) units. The display units are full colour Liquid Crystal Display (LCD) panels, replacing the traditional cathode-ray tubes used in earlier generation cockpits. The F-22 is the first military aircraft to utilize this technology.

At the heart of the avionics suite is the large (8x8 inch), centrally located, Tactical Situation Display (TSD). The TSD is flanked by the smaller (6x6 inch) Attack, Defence and Systems Status MFDs. Information is generously shared across the display screens allowing you to make combat decisions quickly without spreading your attention across a variety of controls and sensors. The TSD provides an overview of the battlefield tactical situation as well as navigational information. The Attack and Defence MFDs work in concert with the TSD to further refine and expand the amount of information available to you as it pertains to weapons delivery and aircraft preservation. The Systems Status MFD rounds out the main avionics suite, providing primary monitoring of the engines and fuel status, stores management, and damage control.

Finally, three small MFDs located beneath the instrument panel glare shield provide detailed damage control reports, backup flight instrumentation, and target images delivered from the Infra-Red Search and Tracking (IRST) system, the Low Altitude Navigation and Targeting System for Night (LANTIRN) system or television guided munitions.

Surrounding the MFDs are pushbuttons that control the various aircraft systems, sensors, weapons, countermeasures, and other functions. In addition, certain display modes provide menus, which refine control further. To select a function or activate a system, click on the appropriate button or menu item with your mouse cursor. Buttons illuminate when the functions they control are activated. Additionally, moving the mouse curse over a button or menu item will pop up a text box that describes the function of that item.

Although there are no analog gauges in the F-22, there is sufficient redundancy among the instrumentation displays to allow you to fly the aircraft even in the event of battle damage to one or more of them. Should you receive damage severe enough to extinguish all the displays, it is likely that you will be forced to eject.

Input from onboard sensors is combined with input from other airborne and ground based sources and shared among the many MFDs available to you. Despite the enormous amount of data, the F-22's avionics is designed to coordinate and display the information in a highly readable form. Wherever possible, distinctive colours and shapes are used to identify and distinguish items of interest and the symbology is consistent across different display units.

The F-22's avionics computers are able to manage the degree to which active and passive systems are utilized through a stepped process of Emissions Control (EMCON) settings. The system divides the airspace around the aircraft into-concentric zones representing graduated degrees of threat. If threats are located at a distance from the

aircraft, the EMCON system will monitor them passively and not break emissions silence in order to maintain stealth. As targets get closer, the EMCON system will gradually, through a series of five steps, increase the degree of attention they receive from active sensors. As EMCON level increases, so too does your ability to bring the F-22's weapons and defensive systems to bear. For maximal stealth operations, the EMCON system can be controlled manually to restrict emissions completely or by degrees.

If attacked by air-to-air missiles, the avionics computers will locate and identify the threat, and provide voice and audio cues to announce it. Countermeasures will be deployed automatically - chaff for radar guided missiles and flares for InfraRed (IR) guided missiles. While these actions speed the response to incoming missile threats and may sometimes be enough to spoof them, you may also need to execute evasive manoeuvres to defeat them. Missile evasion is more completely covered in Chapter 4 'Performance'.

Through its ability to automate the tasks required for navigation, stealth, target acquisition, weapons delivery and defensive systems, the F-22's avionics relieves much of the logistics of getting to the fight, allowing the pilot to concentrate instead on the command decisions required when he arrives. The result is an aircraft with impressive capabilities and unrivaled situational awareness for the pilot who flies it.

Let us take a look at each of the components of the avionics suite in turn, giving an overview of their function and insights into how best to utilize the information they provide to execute missions successfully.

Part I

Radar and Sensors

Dominating the instrument panel is the large, centrally located Tactical Situation Display (TSD), flanked on either side by the Defence and Attack Multi Function Displays (MFDs), with the Systems Status MFD located immediately below the TSD. Sensor data, both from onboard units and downloaded via secure data links from other sources are combined on the TSD to provide you with an accurate, up-to-the-minute picture of the battlefield situation.

The primary onboard sensors consist of the APG-77 radar designed jointly by Westinghouse/Northrop Grumman and Texas Instruments, and the Lockheed/Sanders/General Electric integrated electronic warfare system that includes Infra Red Search and Tracking (IRST), Radar Homing And Warning (RHAW) and Missile Approach and Warning (MAW) systems.

The APG-77 radar unit contains an active array, electronically scanned antenna that features over one thousand separate radiating elements. This design provides the agility, high bandwidth, long range, and high resolution needed to support the F-22's role as an air superiority platform. Unlike older, mechanically driven radar units, this electronically scanned radar is able to build an image of the space in front of the aircraft almost instantaneously. Coupled with the low passive-detection characteristics of the APG-77, these characteristics allow you to approach very close to airborne and ground targets and achieve weapons launch parameters before being detected. Despite its unprecedented capabilities, the APG-77 is, like all radar units, an 'active' system that exposes you to detection by enemy fighters and ground units.

The F-22 can, however, rely in large measure on its impressive suite of 'passive' sensors to detect, track and classify the source of emissions. This provides you with a high degree of situational awareness while maintaining a stealthy profile. The F-22 features large conformal antennas built into the wings, tail and fuselage to provide full coverage of electronic and other energy emissions in the skies around it. These sensors can determine bearing to and, in some cases, even rudimentary range data for surrounding sources. Constant

surveillance is maintained to detect radar locks and missile launches which may threaten the aircraft.

The IRST system can provide passive target imaging and tracking at ranges up to 50 miles. It can also be used to provide launch cues to Sidewinder heat-seeking air-to-air missiles and Maverick air-to-ground missiles without the need to engage any active sensors.

In addition to onboard passive sensors, the F-22 can communicate with Airborne Warning And Control System (AWACS) and Joint Surveillance Target Attack Radar (J-STARS) aircraft via secure data links to receive information on the disposition of friendly, enemy and neutral forces. Inter-flight data links also allow you to benefit from sensor data collected by other combat aircraft, providing the ability to stealthily approach targets while their attention is drawn elsewhere.

Taken as a whole, the F-22's sensor and data gathering abilities provide superior tactical awareness in air-to-air combat, giving you unparalleled first-look, first-shoot, first-kill capabilities.

Overview Of Emissions Control (EMCON) Levels

The avionics computers in the F-22 can, if desired, manage the degree to which active sensors are employed to achieve a balance between stealth, information gathering, presentation of the current tactical situation, and weapons deployment. This is accomplished by designating concentric zones of threat and assigning Emission Control (EMCON) levels. There are five EMCON levels, ranging from 'EMCON 1' where threats are at the farthest reaches of the aircraft's sensors to 'EMCON 5' where the F-22 is well within the weapons deployment envelope of enemy aircraft.

The current EMCON level setting affects a wide variety of systems and displays, from the degree to which the aircraft's radar and communications equipment are enabled for active transmissions, to the range displayed on the various MFDs, to the activation of weapons and defensive systems. While the actual operation of the EMCON system is still classified, here is a breakdown of how the EMCON levels are defined within F-22 ADF/TAW.

EMCON LEVEL1

- The APG-77 radar is disabled.
- The communications radio is set for receive mode only (TAW).
- The secure data link systems are set for receive mode only.
- The IRST is designated as the primary onboard detection system and is operational to its maximum range of 50 miles.

- The RHAW system is enabled and monitors for enemy radar activity out to a range of 50 miles.
- The MAW system is enabled and monitors for enemy missile launches.
- Countermeasures are only released manually.
- The Tactical Situation Display and the Attack and Defence MFDs are set to display their maximum range of 200 miles when Auto EMCON mode is engaged.
- Radar guided air-to-air missiles (AIM-120s) are disabled.
- Radar guided Harpoon air-to-ground missiles are disabled.
- InfraRed Sidewinder air-to-air missiles may be targeted and fired using the IRST for tracking and acquisition.
- Television guided Maverick air-to-ground missiles may be fired using the IRST for tracking and acquisition.

EMCON LEVEL 2

- The APG-77 radar is designated as the primary onboard sensor and is enabled for airborne target identification and tracking only. Target lock is disabled.
- The communications radio and secure data link systems are fully enabled to transmit and receive.
- The IRST is active and may be used to acquire, designate and lock targets for the Sidewinder and Maverick missile systems.
- The RHAW system is enabled and monitors for enemy radar activity out to a range of 100 miles.
- The MAW system is enabled and monitors for enemy missile launches.
- Countermeasures are only released manually.
- The Tactical Situation Display and the Attack and Defence MFDs are set to display a range of 100 miles when Auto EMCON mode is engaged.
- Radar guided air-to-air missiles (AIM-120s) are disabled.
- Radar guided Harpoon air-to-ground missiles are disabled.

EMCON LEVEL 3

- The APG-77 radar is designated as the primary onboard sensor and is fully enabled for airborne target identification, tracking and weapons lock.

- The communications radio and secure data link systems are fully enabled to transmit and receive.
- The IRST is active and may be used, in addition to the APG-77, to acquire, designate and lock targets for the Sidewinder and Maverick missile systems.
- The RHAW sytem is enabled and monitors for enemy radar activity out to a range of 150 miles.
- The MAW system is enabled and monitors for enemy missile launches.
- Countermeasures are only released manually.
- The Tactical Situation Display and the Attack and Defence MFDs are set to display a range of 50 miles when Auto EMCON mode is engaged.
- Radar guided air-to-air missiles (AIM-120s) are enabled.
- Radar guided Harpoon air-to-ground missiles are disabled.

EMCON LEVEL 4

- The APG-77 radar is designated as the primary onboard sensor and is fully enabled for airborne target identification, tracking and weapons lock.
- The APG-77 radar is enabled for ground based target identification and tracking only. Target lock of ground mobiles and ships is disabled.
- The communications radio and secure data link systems are fully enabled to transmit and receive.
- The IRST is active and may be used, in addition to the APG-77, to acquire, designate and lock targets for the Sidewinder and Maverick missile systems.
- The RHAW system is enabled and monitors for enemy radar activity out to a range of 200 miles.
- The MAW system is enabled and monitors for enemy missile launches.
- Countermeasures are only released manually.
- The Tactical Situation Display and the Attack and Defence MFDs are set to display a range of 40 miles when Auto EMCON mode is engaged.
- Radar guided air-to-air missiles (AIM-120s) are enabled.
- Radar guided Harpoon air-to-ground missiles are disabled.

EMCON LEVEL 5

- The APG-77 radar is designated as the primary onboard sensor and is fully enabled for both airborne and ground based target identification, tracking and weapons lock.
- The communications radio and secure data link systems are fully enabled to transmit and receive.
- The IRST is active and may be used, in addition to the APG-77, to acquire, designate and lock targets for the Sidewinder and Maverick missile systems.
- The RHAW system is enabled and monitors for enemy radar activity out to a range of 250 miles.
- The MAW system is enabled and monitors for enemy missile launches.
- Countermeasures are automatically released as appropriate to the incoming threat.
- The Tactical Situation Display and the Attack and Defence MFDs are set to display a range of 11 miles when Auto EMCON mode is engaged.
- Radar guided air-to-air missiles (AIM-120s) are enabled.
- Radar guided Harpoon air-to-ground missiles are enabled.

Manual control of the current EMCON Level is available at any time. While it is possible to manually increase the EMCON Level, this is rarely a necessary or prudent thing to do. Reducing the EMCON level is another matter however. A pilot may wisely choose to manually set EMCON Level 1 when stealth is critical, for example, during a surprise bombing attack, in order to maintain emissions silence

EMCON Levels may be set manually by depressing the appropriate button on any of the sensor MFDs with the mouse cursor or by pressing the E key on the keyboard to bring up the EMCON Level menu.

Part II Tactical Situation Display

As previously noted, this large, full-colour MFD takes centre stage on the F-22's instrument panel. The primary function of the Tactical Situation Display (TSD) is to provide you with a God's eye view of the physical and tactical environment around your aircraft out to a maximum range of 250 miles. Press the 2 key on the numeric keypad to bring up the TSD (Figure 1).

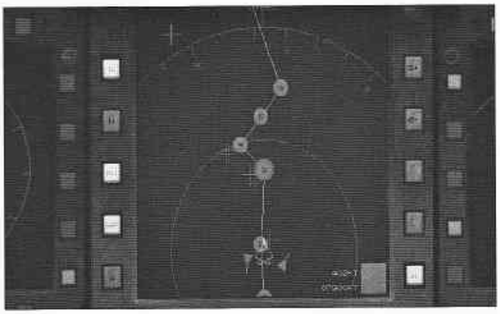


Figure 1

The view presented on the TSD is 'top-down', with your aircraft's position represented by an F-22 icon near the bottom of the display. Your flight path always points to the top of the screen. As your heading changes, the display will rotate around the F-22 icon.

The data gathered by the F-22's own onboard sensors, as well as that obtained from linked sources, is summarised on the TSD to draw an extraordinarily detailed overview of the battlefield. The TSD displays both airborne and ground based target data, and can overlay all this with the current waypoint route and maps of the surrounding terrain. A pair of semi-circular arcs, marked with their distance from your aircraft, subdivides the display. The outer arc, drawn slightly inside the maximum currently displayed range, has compass marks placed at 10-degree intervals in order to assist in determining the bearing to targets or other items of interest.

Sensor range is controlled automatically when Auto EMCON mode and is designed to present you with the most useful zoom level for the threat situation at hand. Range can be increased or decreased manually however, either by clicking on the buttons marked 'S+' and 'S-' located along the upper right-hand side of the TSD, or by pressing the Grey 'Page Up' or 'Page Down' keys on the keyboard. Note that sensor ranges set manually will not 'stick' unless you also take manual control of EMCON Levels.

The displayed range can be adjusted from a minimum of just less than 15 miles, to a maximum of about 250 miles in five discrete steps. The outer arc, drawn slightly inside the displayed maximum range, appears

at 11, 40, 50, 100 or 200 mile ranges, depending on the current zoom level. The inner arc is drawn at one-half the distance of the outer arc. Note that adjusting the sensor range affects not only the TSD, but will also increase or decrease the range displayed on the Attack and Defence MFDs simultaneously.

At the top of the TSD are buttons that control the current EMCON Level settings. The left-most button, marked 'AE', engages automatic EMCON control; the two buttons immediately to the right, marked 'E-' and 'E+' cycle EMCON levels down and up respectively. The EMCON Level may be set manually by pressing the 'E' key and making the desired selection from the EMCON Level menu. The current EMCON status appears in the upper left-hand corner of the display.

Your aircraft's current heading is indicated at the top of the display. Your airspeed and altitude are shown in the lower right-hand corner of the display along with an artificial horizon indicator. The button in the lower right-hand corner, marked 'H', toggles the small artificial horizon display on and off. Heading, airspeed and altitude information is provided at all times.

The button at the lower left side of the TSD, marked 'A', switches the information displayed on the MFD from tactical display to autopilot control display mode. Heading autopilot mode is displayed in Figure 2, one of seven different modes available. A complete description of the autopilot and its functions can be found in Part IX of this Chapter.

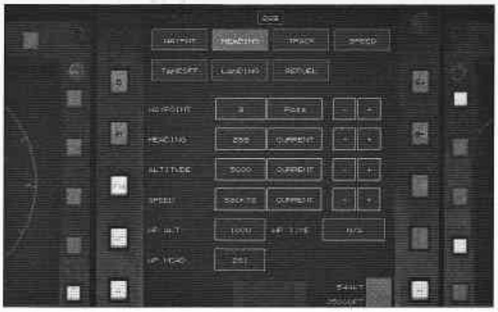


Figure 2

Several autopilot modes are available and are controlled by clicking the mouse button in the displayed menu boxes. A complete discussion of autopilot procedures is provided in Chapter 3, 'Learning to Fly.'

To restore the TSD to its default display mode, press the 'D' button located in the upper left-hand corner.

The remaining buttons along the left side of the TSD control the display of navigational aids. The button marked 'M' toggles a physical map overlay on and off. Immediately below it is a button, marked 'PN', which toggles the display of geographic place names on and off. And finally, the button marked 'WP' toggles the display of the stored waypoint route.

The route is displayed as a set of lines connecting individual waypoints. Numbered green circles depict normal waypoints and the currently selected waypoint is highlighted for emphasis. Take off and landing waypoints are green circles marked with 'T' and 'L' respectively. A small, solid red triangle, rather than a green circle, marks the primary strike waypoint if one has been programmed.

The 'WE' button, located in the lower left-hand corner, activates the waypoint editor. This allows you to modify the stored route to accommodate changes in the tactical situation since take-off. When activated, existing waypoints may be moved, deleted or have their altitude adjusted. New waypoints may also be inserted between any two existing waypoints. Changes can only be made for waypoints located within 100 miles of your current position.

While in waypoint edit mode, the map and place names display is also activated. In addition, menu boxes will appear allowing you to delete a waypoint or modify its programmed altitude. Clicking the mouse cursor on any 'normal' waypoint will highlight it in red and enable modifications. Clicking on the '+' and '-' boxes changes the stored altitude. Clicking on 'Delete' will remove the waypoint. You may move the waypoint by simply dragging it to a new location. Finally, clicking on the blue box located between any two existing waypoints creates a new waypoint, which can be modified as you wish. Click on the 'OK' button when you are through making changes.

To exit the waypoint editor and return the TSD to its normal display mode, simply press the  button in the upper left-hand corner of the display.

The central button along the bottom of the TSD, marked 'OS', controls whether data displayed is coming solely from the F-22's own sensors, or is combined with data from other sources such as AWACS, J-STARS or other data linked aircraft. To its right, the buttons marked 'GT' and 'AT', toggle whether ground targets and air targets are displayed on the TSD. Special care should be exercised when toggling these options as targets and threats will disappear not only in the TSD, but also in the Attack and Defence MFDs.

TSD Target Symbology

With few exceptions, the colours and shapes of the icons used to represent different types of targets are consistent across the various MFDs. This makes it easy for you to interpret the data presented regardless of which display you are looking at. We will note the differences when discussing the Attack and Defence MFDs, but for now, let us look at the symbology used in the TSD.

Icons and target data blocks are colour coded to represent their allegiance - enemy, neutral or allied. Enemies are red in colour, neutrals are dark blue. Allies are green, your wingmen are light blue. Icon's whose allegiance is unknown are yellow-green in colour.

Aircraft are designated by solid triangles. A line extends from the triangle to designate the current heading. The heading line is approximately half the height of the triangle for subsonic aircraft, and roughly the same height as the triangle for supersonic aircraft.

If the mouse cursor is placed over an airborne target, a data block appears in the lower left-hand corner of the TSD, providing you with additional target information. The first line identifies the target type, for example, Su-27, MiG-21, and so on. If the game difficulty level has been set to either easy or medium, the letter 'T' will appear in parenthesis after the target type if this is a primary target for mission completion. In addition, a line will appear listing the target's callsign. At the hard difficulty level in F-22 ADF, the primary target indicator and callsign line is absent. In TAW, only the primary target indicator is removed, the callsign line remains. The mission briefing will describe your primary targets, and you will need to rely on the target type alone in order to determine whether a target is of primary importance to mission completion. The target's altitude above sea level in feet is shown next, followed by the target's altitude, the target's current heading and range. The final line indicates the target's current airspeed in knots.

Ground radar, Anti-Aircraft Artillery (AAA) or Surface-to-Air Missile (SAM) sites are designated with pentagons. This allows you to quickly identify which ground targets that represent the greatest long-range threat. You can then choose either to strike at them first or steer well clear of their detection and firing envelopes.

Ships are designated by inverted 'T' symbols. Ships with radar tracking and fire capabilities are shown as coloured symbols to identify their allegiances. Most others are shown as yellow-green symbols.

As with airborne targets, moving the mouse cursor over an enemy AAA, SAM, radar site or ship will bring up a target data block in the lower left-hand corner of the TSD. Target type is shown on the first line, for example, ZSU-23, SA-6, Destroyer, etc.. Bearing and range to the target is shown on the second line. The third line is not relevant to game play. At easy or medium difficulty levels, the primary target symbol '(T)' will appear alongside the target type. At the hard level, the player will have to rely on the mission briefing and the target type alone to identify priority targets.

Ground mobiles such as humvees, trucks, tanks, etc., are shown as upright crosses. No colour-coding is used; all ground mobiles are yellow-green in colour. Target information is not available and consequently you should take care when overflying ground mobiles in enemy territory. While 'Triple-A' or SAMs can completely ruin your day, gunfire from other enemy forces may cause sufficient damage to your aircraft as to preclude completion of your mission. Inaddition, avoiding ground mobiles while in enemy territory increases your chances of avoiding detection if the mission calls for a stealthy profile.

Fixed ground targets are designated by an upright triangular outline. These are typically preprogrammed primary strike mission objectives

such as Command and Control buildings, political sites, factories and other high priority targets. Although noted here for completeness, this icon does not appear on the TSD. It does appear on the Attack and Defence MFDs however. On the TSD, the strike waypoint is always located directly on top of the primary strike target and serve to designate it. Toggling ground targets off has no effect on this icon on the Attack and Defence MFDs. Toggling the waypoint display off, however, will remove the primary strike waypoint symbol from the TSD.

As with ground mobiles, no target data is presented for primary strike targets when the mouse cursor is placed over the icon. You should consult the mission briefing screen for information on primary strike targets.

On some missions, 'kill boxes' will appear in the TSD. These red, rectangular boxes, represent 'free fire zones.' Any ground targets located within a kill box may be presumed to be hostile, and should be engaged and destroyed.

Air-to-Air, Air-to-Ground and Surface-to-Air missiles are all shown as small, rapidly moving yellow squares. In the TSD, there is no visual distinction between radar guided and IR missiles. There is also no visual indication as to whether an incoming missile is currently locked onto your F-22 or not. To determine whether you are at immediate risk, you should pay close attention to launch warnings generated by the avionics as well as observe the motion of missiles on the TSD or other MFDs. A more complete discussion of missile avoidance techniques is covered in Chapter 4, 'Performance'.

The F-22 utilizes a 'Shoot List' in order to lock on to, track, and fire upon targets. Shoot lists allow up to ten targets to be designated and attacked quickly and efficiently. A shoot list may be generated automatically by the F-22's avionics, or targets may be added manually to a shoot list. To build a shoot list automatically, either press the T key or click on the 'SL' button on the Attack MFD. To add targets to the shoot list manually, either click on the selected target in one of the MFDs or by press the S key when the target is padlocked. The currently selected target's icon will appear overlaid on a solid white circle. Other targets on the shoot appear as icons circumscribed by a hollow white circle. Using shoot lists will be covered in much greater detail later in this Chapter.

Part III Attack MFD

The Attack MFD is the large display unit located to the right of the TSD. The primary function of this display is to expand on the situational data presented on the TSD and provide you with a more detailed look at how your weapons can be deployed against enemy targets. Pressing the [3] key on the numeric keypad will bring up the Attack MFD (Figure 3).

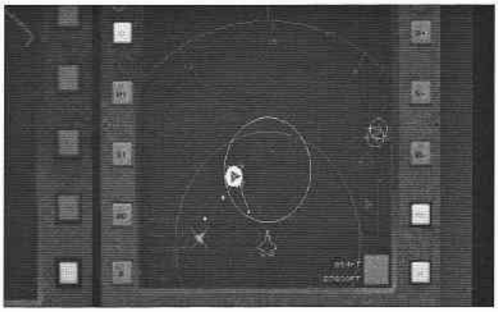


Figure 3

The viewpoint presented by the Attack MFD is identical to the one shown on the TSD - a 'top-down', God's eye view. An F-22 icon near the bottom of the display marks the position of your aircraft and your flight path always points to the top of the screen. Your heading is indicated at the top of the display. As your heading changes, the display will rotate around the F-22 icon. A pair of semi-circular arcs, marked with their distance from your aircraft, provides a visual reference and scale. The outer arc is subdivided by compass marks at 30-degree intervals that help simplify determining the bearing to targets.

Known targets within 250 miles are displayed on the Attack MFD. Sensor range is controlled in the same manner as indicated previously for the TSD. The currently selected weapon type and number of remaining rounds is displayed in the upper right-hand corner of the display. Current airspeed and altitude are shown in the lower right-hand corner of the display along with an artificial horizon indicator. The current EMCON setting appears in the upper left-hand corner of the display. Controls for adjusting sensor range and EMCON settings function exactly as noted earlier for the TSD.

The target symbology displayed by the Attack MFD is identical to that employed by the TSD, and as with the TSD, moving the mouse cursor over a target will present a data block for that target in the lower left-hand corner of the display. Clicking on a target will manually add it to the current shoot list. A shoot list can be generated automatically by pressing the 'SL' button, centrally located along the right-hand side of the display. Pressing the [T] key on the keyboard will also generate

a shoot list automatically. Since the automatically generated list does not always rank targets accurately based on their relative threat or priority towards mission completion, there are many times where it is more advisable to add targets to the shoot list manually. Shoot lists will be covered in more detail later in this chapter.

The buttons labeled 'AC' and 'MC', located near the upper right-hand corner of the Attack MFD control whether target cycling on the shoot list is automatic or manual. Pressing the **SHIFT-C** key can also toggle target cycling mode. In automatic mode, the currently selected weapon is automatically locked onto the next target on the shoot list once the current target has been fired upon. In manual mode, or if the cannon is the currently selected weapon, target lock is maintained until the current target has been destroyed. Pressing the **C** or **X** keys will manually cycle forwards or backwards through the shoot list.

The Attack MFD can display altitude data for multiple airborne targets simultaneously, allowing you to visualize the third dimension - the relative altitude of targets - without requiring additional display modes. Traditional avionics systems required the pilot to choose between seeing either relative altitude or relative position on targets, but not both at the same time. The avionics suite in the F-22 does away with this limitation, providing you with information about the vertical component of the tactical situation without sacrificing the display of the horizontal.

Along the left-hand side of the display is a graphical 'altitude above sea level' scale consisting of eight green tick marks. The lowest, unlabeled tick mark represents sea level. The tick marks labeled one through seven correspond to 10,000-foot intervals above sea level. The white line to the right of the scale represents the F-22's current altitude. When an airborne target is selected, a solid caret will appear corresponding to the target's current altitude. If multiple targets are selected, a numbered caret will appear for each target in the shoot list. The current target is always shown as a solid caret, other targets in the shoot list are shown as open carets. The 'AD' button, located to the left of the altitude bar, toggles this display on and off.

A blue range bar for the currently selected weapon appears along the right-hand side of the display above the artificial horizon indicator. The range bar will shrink or grow to reflect how of the F-22's speed and altitude affects the effective range of the currently selected weapon. For moving targets, the relative speed and heading of the current target will also effect the size of the range bar. The horizontal tick mark at the top of the bar represents the maximum range of the currently selected weapon. When a target is selected, a solid caret will appear, indicating the target's current range with respect to the effective range of the selected weapon. If multiple targets are selected, a numbered caret will appear for each target in the shoot list. The

current target is always shown as a solid caret, other targets in the shoot list are shown as open carets. The 'RD' button, located to the right of the range bar, toggles this display on and off.

A circular white ring will appear above the F-22 icon on the Attack MFD whenever Air-to-Air weapons are selected. This indicator is a graphical representation of the current 'Probability of Kill' (PK) level for the selected weapon and target. The F-22's avionics continually calculates the PK based on current firing conditions. As PK increases, the diameter of the PK indicator circle will increase. See Chapter 5, 'A2A Weapons' for a complete discussion of how to interpret the PK indicator and effectively use your A2A weapons.

When JDAMs are selected, an ovoid shape indicates the acceptable drop envelope. See Chapter 7, 'A2G Combat' for more details on how to use JDAMs and other A2G ordnance.

Missiles appear as small, rapidly moving yellow squares. As is the case with the TSD, no indication is given to distinguish incoming missiles that are currently tracking your aircraft. Missiles launched by your F-22 will, however, display a white line connecting them to their target as long as they continue to track the target. If the target succeeds in breaking the lock or spoofing the missile, the white line will disappear.

The buttons labeled 'II' and 'WI' along the left side of the Attack MFD replace the default display with video images taken from the either the IRST system, as shown in Figure 4, or the high resolution television camera of the Maverick missile.

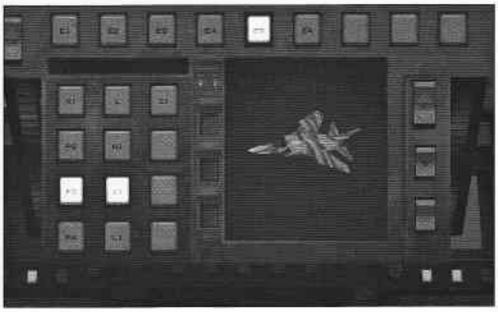


Figure 4

The buttons along the bottom of the Attack MFD control the display and function of the LANTIRN system, which is used primarily for targeting laser-guided bombs. The 'L' button toggles the LANTIRN display on and off and the 'LR' button resets the LANTIRN system to its default mode. The 'ZI' button toggles the image between a zoomed-in and normal angle mode. The 'LT' button locks the LANTIRN system onto the selected target and activates the laser target designator. Finally, the 'LM' button switches the LANTIRN between 'slaved' and 'free' modes. The LANTIRN mode may also be selected by pressing the L key.

While in LANTIRN mode, the Attack MFD displays video images taken from the LANTIRN camera. By default, the camera is initially pointed directly ahead of the F-22's flight path, un-zoomed and in 'slaved' mode. A large cross hair pinpoints the focus of the camera's attention. The F-22's altitude is shown in the upper left-hand corner, below the EMCON setting indicator. The currently selected weapon,

and number of weapons remaining, is displayed at the bottom of the screen.

A small green square provides a graphical indication of where the camera is pointed. If one imagines that the centre of the cross hairs corresponds to the position of the F-22, the square marks the location where the LANTIRN camera is aimed, either ahead or behind the F-22 or to one side or the other. Pressing the 'LR' button will reset the camera to face forward in normal angle mode.

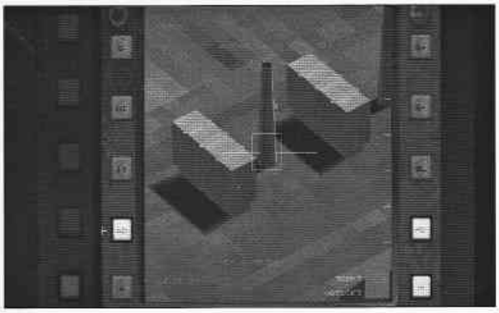


Figure 5

Above and to the left of the cross hair is an indicator for 'slaved' or 'free' modes. When in slaved mode, the LANTIRN camera is automatically pointed at the currently selected target. In free mode, the LANTIRN cameras can be controlled independently of the selected weapon. Use the grey arrow keys to slew the camera.

Above and to the right of the cross hair is an indication of the horizontal distance between the F-22 and the point currently under the intersection of the cross-hair lines. When the LANTIRN system is locked on a target, the letter 'L' will flash to indicate that the laser is firing. A large square will also appear at the centre of the cross hairs to mark the area where the bomb will impact. Figure 5 shows how the LANTIRN display appears when locked on to the smokestack between the two factory buildings.

Tick marks along the right-hand side of the display serves as a 'time to release' indicator. When a target is locked, a thick line - the release cue - will rise through the indicator. When the release cue reaches the top, the weapon is within launch parameters. A 'Shoot' cue will appear below the aiming cross hairs and remain lit as long as launch parameters are not exceeded.

The laser must remain locked on the target until impact. When a weapon is fired, a 'Time to Impact' countdown timer will appear under the range to target indicator. The aircraft must be steered in such a way as to maintain a line of sight between the belly of the F-22 and the target. The cross hair will remain green as long as these conditions are met and will turn white if the laser cannot 'see' the target.

More information on the use of laser guided bombs and the LANTIRN targeting system is provided in Chapter 7, 'A2G Combat'.

The Attack MFD can be configured to display the controls for the autopilot by pressing the 'A' button, located in the lower left-hand corner. See Chapter 3, 'Learning to Fly' for a complete description of how to use the autopilot.

To return the Attack MFD to its normal display mode from LANTIRN, IRST, weapons image or autopilot mode, press the 'D' button in the upper left-hand corner.

Part IV Defence MFD

The Defence MFD is the large display unit located to the left of the TSD. This display expands on the situational data presented on the TSD by providing you with additional information about airborne and ground-based threats in a 360-degree field around the aircraft. Pressing the [1] key on the numeric keypad will bring up the Defence MFD (Figure 6).

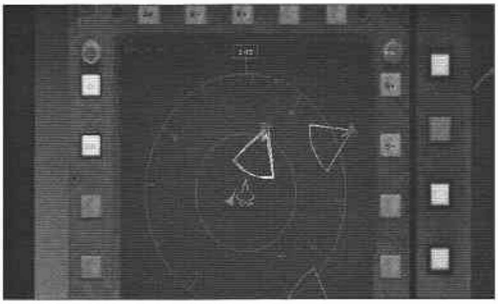


Figure 6

The view presented by the Defence MFD is, like the TSD and Attack MFD, a top-down display with a maximum displayed range of 250 miles. However, unlike the other MFDs, the F-22 icon is located in the centre of the display.

Your flight path always points towards the top of the screen, and your current heading is indicated at the top of the display. As you manoeuvre, the display rotates around the F-22 icon. A pair of range circles, marked with their distance from your aircraft, provides a reference scale. The outer circle is subdivided by compass marks at 30-degree intervals. Airspeed and altitude are shown in the lower right-hand corner of the display along with an artificial horizon indicator. The current EMCON status appears in the upper left-hand corner of the display. Controls for adjusting sensor range, EMCON Level settings and artificial horizon display function exactly as they do on the Situation and Attack displays.

The target symbology displayed by the Defence MFD is identical to that employed by the Situation and Attack displays, however additional data is presented as is pertinent to defensive operations. Once again, moving the mouse cursor over a target will present a data block for that target in the lower left-hand corner of the display.

The Defence MFD is capable of showing enemy radar scan ranges as well as enemy target locks. A white cone projecting from the 'nose' of enemy aircraft icons depicts the detection range of their search and targeting radar. Similarly, a white circle surrounding enemy SAM, AAA and ground radar units outlines the extent of their detection and targeting range. The 'ER' button, located in the upper right-hand corner of the MFD, toggles the display of enemy radar coverage on and off.

The displayed detection ranges are estimates only, not absolute values. You should treat them as areas in which detection is nearly certain. Detection at longer ranges is certainly possible as the capabilities of any given radar source may exceed the displayed ranges. Consequently, you should not assume that skirting the edges of an enemy's radar envelope guarantees that you remain undetected. In addition, enemy AWACS radar coverage may reveal your position to surrounding forces and this is NOT displayed on the Defence MFD.

The displayed detection ranges are dynamic and will shrink or grow depending on the size of your F-22's Radar Cross Section (RCS). Your current speed, altitude, climb or dive rate, and bank angle all affect the size of your RCS, as does any external stores you may be carrying. As a rule, flying wings level, low, and slow reduces your RCS, and provides you with the greatest degree of stealth.

Unless you intend to engage and destroy displayed enemy fighters or ground units, you should steer well clear of their radar coverage in order to avoid detection. Be sure to keep a close eye on the movements of enemy flights around you. Should one turn unexpectedly in your direction, you may be detected and fired upon.

If an enemy radar unit achieves a radar lock, a solid white line will be drawn between the radar unit and the F-22 icon on the Defence display. Once again, unless you intend to engage and destroy the enemy units, you should manoeuvre so as to break the lock and foil reacquisition. Alter your altitude, speed, aspect angle and bearing from the locking targets and, if possible, use terrain masking to make good your escape.

The buttons along the bottom of the MFD provide manual control of countermeasure releases. Pressing the middle button will release a packet of radar reflecting chaff in order to blind an incoming radar guided missile. Pressing the button to the right of the chaff dispenser will release a high intensity flare designed to attract heat-seeking missiles away from your aircraft. Pressing the ';' (semicolon) and '''(single quote) keys will also release chaff and flares respectively. In addition, pressing the grey 'Insert' or 'Delete' keys will release chaff and/or flares as is appropriate to the incoming missile threat.

In the original F-22 ADF release, the button to the left of the chaff dispenser was supposed to release a decoy drone which mimicked the radar and infrared signature of the F-22. Unfortunately, this feature was never implemented in the game. With the release of F-22 Total Air War, this feature has been removed altogether.

Part V Systems MFD

The Systems MFD is located between the pilot's knees, below the TSD. This unit provides primary control over weapons release mode settings and the Instrument Landing Systems (ILS). In addition, status display screens for the engines, fuel system, stores, and damage control are also available on the Systems MFD. Pressing the 'Insert' key on the numeric keypad will bring up the Systems MFD.

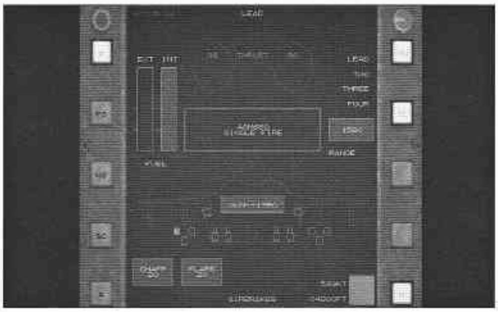


Figure 7

In its default 'Engine and Systems' display mode (Figure 7), the current engine power setting is displayed on two simulated gauges, one for each of the engines. Percentage of military - or 'dry' - thrust is indicated numerically. Values over 100 percent indicate that raw fuel is being dumped into the afterburners - 'wet' thrust. The colour of the gauges is an indication of the health of engines. A healthy engine's gauge appears green. If an engine is moderately damaged, the corresponding gauge will change to yellow, or red if the damage is severe. If an engine fire occurs, a flashing red 'FIRE' box will appear to the right of the gauges.

To the left of the engine gauges is a pair of vertical bars that show fuel remaining in the internal and external (if any) fuel tanks. Below and to the right of the engine gauges, is a continuously computed estimate of the range of the F-22 based on current fuel consumption conditions. Altitude, speed, external stores and damage all contribute to increasing or decreasing the available range.

The schematic outline of an F-22 graphically displays the stores currently onboard. A quick glance here will show what weapons, fuel tanks, etc. remain on the F-22 and whether they are being carried internally or externally. Air-to-Air weapons are shown as blue squares, Air-to-Ground weapons appear as green squares. The currently selected weapon is highlighted. You can select any weapon simply by clicking on it. The status of weapons bay doors - open or closed - is indicated by a line drawn across the appropriate opening in the fuselage schematic. The schematic will also indicates whether internal weapons ejector racks are currently extended into the air stream.

Once again, colour is used to provide a quick way of determining the status of your F-22. If all aircraft systems are operational, the schematic will be green. As damage accumulates, the colour will change first to yellow, and then red, as it becomes more severe.

Immediately above the F-22 outline, a text box displays information on the currently highlighted weapon system or store, along with the current weapons release mode settings. In ripple mode, the selected numbers of weapons are released sequentially according to the current delay settings. In salvo mode, the selected numbers of weapons are released simultaneously. Salvo mode is only available for Air-to-Ground weapons. Ripple mode is available for both Air-to-Air and Air-to-Ground weapons.

Buttons along the bottom of the Systems MFD control release settings. The button marked 'FM' toggles between single, ripple or salvo fire modes. Pressing the F key on the keyboard will also toggle the fire mode. The 'F+' and 'F-' buttons increase or decrease the number of weapons released by a single press of the trigger in ripple or salvo mode. The 'D+' and 'D-' buttons increase or decrease the delay between weapons releases when in ripple mode.

The number of remaining countermeasures is indicated in the lower left-hand corner of the display. An artificial horizon and readouts of the F-22's current altitude and airspeed are displayed in the lower right-hand corner. Finally, an airbrake indicator along the bottom of the display will illuminate in red whenever the airbrake is deployed.

A listing of the aircraft in your flight appears above the range indication. If you are flying solo, only the word 'Lead' will be displayed. If wingmen are accompanying you on the mission, they will be listed as 'Two', 'Three' and 'Four'. The text colour allows you to quickly determine the condition of each your wingmen. White text indicates no damage, yellow text indicates moderate damage, and red indicates severe damage. If a wingman is shot down, his designation will disappear from the listing.

You can toggle the default status display between that of your own aircraft and that of your wingmen's by pressing the 'WS' button, located on the left-hand side of the Systems MFD. Title text at the top of the Systems MFD reminds you of which aircraft you are currently viewing. When viewing a wingman's status, his default weapons loadout and remaining ordnance are shown in the centre of the display. You can also see what countermeasures remain as well as his fuel status as shown in Figure 8.

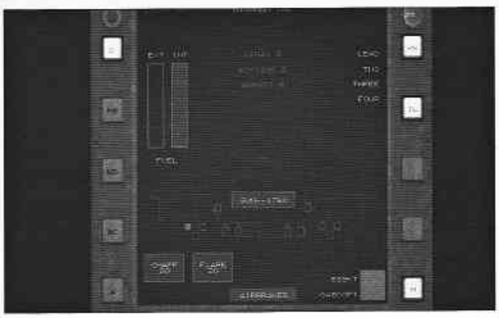


Figure 8

The buttons along the left-hand side of the Systems MFD control the different display modes presented

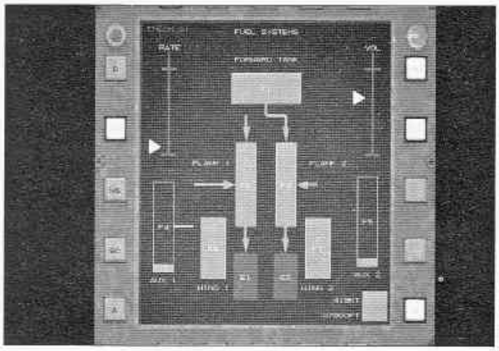


Figure 9

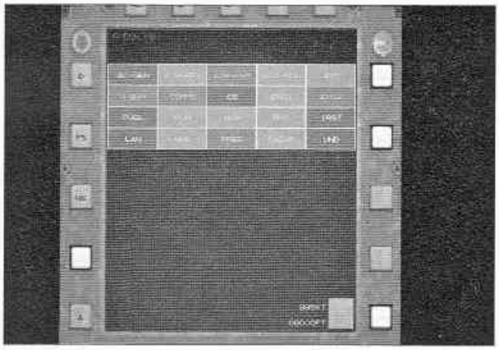


Figure 10

on the screen: fuel system mode, systems check and damage reports mode, and autopilot mode.

Pressing the 'FS' button brings up a detailed schematic of the F-22's fuel system, as shown in Figure 9. Fuel remaining is depicted graphically for all of the various internal and external fuel tanks. In addition, gauges in the upper left and right-hand corners of the display indicate the fuel flow rate and fuel load. Small triangular carets move up and down along the gauges as current flow and load levels change.

The 'SC' button brings up a system check and damage report screen (Figure 10). A grid of text boxes provides a quick overview of damage to the F-22's systems. The background colour of a box indicates the current status of that system. A green box indicates that the system in question is undamaged, or at least 60 percent operational. When a system drops below 60 percent operation status, the box for that system will turn yellow. If a system is damaged severely - less than 30 percent operational - or fails entirely, the box will turn red. Detailed damage reports are also available on the Combined Communications & Warning(CC&W) MFD.

Here is a rundown on what systems are referenced by the abbreviations in the status boxes. (Table 1).

AC-GEN	Electrical generator
AIR-BRK	Airbrake
AIR-FRM	Airframe
AUX-POW	Auxiliary power unit
AVI	Avionics computer and display systems
W-BAY	Weapons bay doors or weapons ejectors
COMMS	Communications radios and uplink data systems
CS	Control surfaces - flaps, ailerons, rudders, tailplanes,etc.
ENG1	Port side engine
ENG2	Starboard side engine
FUEL	Fuel tanks and pumps
GUN	M61A2 cannon
HUD	Heads Up Display and/or Helmet Mounted Display systems
HYD	Hydraulic actuator systems

IRST	Infra-Red Search and Tracking system
LAN	LANTIRN targeting system and laser designator unit
NWS	Nose wheel steering system
PRES	Cockpit pressure and oxygen systems
RADAR	Radar systems
UND	Undercarriage - landing gear

The 'VW' button in the upper right-hand corner toggles vocal warnings from 'Bitching Betty', the voice of the avionics computer, on and off. Just below the vocal warning button is the 'IL' button, which controls whether or not the Instrument Landing System (ILS) boxes are displayed in the HUD and HMD. A complete discussion of landing procedures is provided in Chapter 3, 'Learning To Fly'.

The buttons that control EMCON Level, sensor scan range, artificial horizon and autopilot function identically as those found on the other MFDs. The 'D' button, located in the upper left-hand corner, restores the default engine and systems display.

Part VI Supplementry MFDs

The Up Front MFD

The Up Front MFD is located just below the HUD, between the CC&W and Artificial Horizon MFD units. Pressing the S key on the numeric keypad will bring up this display. The Up Front Panel consists of a small Video Display Unit (VDU), as well as buttons and rocker switches that control a variety of aircraft systems. These include: the communications radio frequency, the Emissions Control (EMCON) settings, HUD modes, the main munitions bay doors, the landing gear and the Air Combat Manoeuvres Instrumentation (ACMI) recording unit. In addition, warning and status indicators along the left side of the display unit provide a visual cue for engine status, enemy radar lock, and incoming missile identification - radar or infrared.

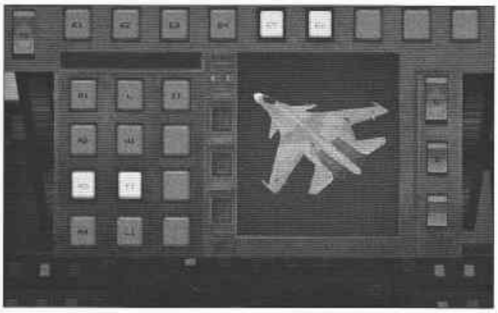


Figure 11

The Up Front MFD displays video obtained from the InfraRed Search and Track (IRST) system, the Low Altitude Navigation and Targeting System for Night (LANTIRN) system or the AGM65G Maverick missile. The IRST image can be either an airborne, as seen in Figure 11, or ground based target depending on the selected HUD and weapons mode. The LANTIRN image is used primarily for ground attack, however it may also be employed as a ground-spotting unit for visual navigational purposes.

The buttons along the top of the Up Front panel, marked 'E1' through 'E5' and 'EA', control and indicate the current EMCON Level settings as well as whether Auto EMCON is engaged. The button on the far right cycles the current HUD mode selection. The toggle switch on the far left controls the ACMI recording unit.

Along the right-hand side of the Up Front display unit are toggle switches which control the landing gear (top switch, labeled 'G') and main munitions bay doors (middle switch, labeled 'B'). These switches illuminate when the gear is down and/or the bay doors are open.

The array of buttons along the left side of the Up Front panel control the communications radio frequency as well as selecting what image is displayed on the Up Front MFD unit.

- 'R1' through 'R4' select radio frequencies 1 through 4.
- 'L' displays the video image from the LANTIRN unit.
- 'WI' displays the video image from a Maverick missile.
- 'II' displays the video image from the IRST unit.
- 'LI' locks a Maverick missile to the target displayed by the LANTIRN unit.
- 'ZI' toggles the image zoom level.

Four warning and indicator lights appear just to the left of the VDU. The top indicator is actually a pair of lights that illuminate whenever the engines are running. Immediately below the engine indicator is the radar lock warning light. This lamp will illuminate whenever an enemy tracking radar locks on to your F-22 ADF. The next two lamps illuminate whenever a missile lock and launch is detected by the avionics. If the missile is heat seeking, the lower of these lamps will light up. If the missile is radar guided, the upper lamp will illuminate.

Warning (CC&W) MFD

The CC&W MFD is located on the left side of the cockpit just below the glareshield. Pressing the '4' key on the numeric keypad will bring up this display (Figure 12). The CC&W unit displays text information regarding aircraft system status, malfunctions and other warnings generated by the aircraft's avionics.

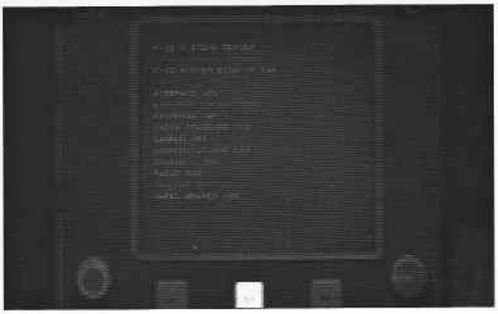


Figure 12

There are three buttons along the bottom for the CC&W MFD. From left to right, these buttons cycle the active radio frequency, toggle the display of text data, and generate a systems status/damage report.

The systems status/damage report generated by the CC&W MFD provides a detailed listing of the operational level, expressed as a percentage of full functionality, for all damaged aircraft systems. Colour-coding makes rapid identification of damage levels easier. Lightly damaged systems - those retaining at least 60 percent functionality - are displayed in green text. Moderately damaged systems - between 30 and 60 percent operational status - are displayed in yellow text. Severely damaged - below 30 percent operational status - or failed systems are displayed in red.

Overview of the Artificial Horizon MFD

The Artificial Horizon MFD is located under the glareshield opposite from the CC&W MFD and may be activated by pressing the '6' key on the numeric keypad (Figure 13). This display replaces the old-fashioned gyroscopic artificial horizon found in most aircraft. The unit serves as a backup to the HUD and displays a duplicate of the pitch ladder, heading and altitude data. Aircraft speed also appears on this display, but is presented True Air Speed (TAS) - ground speed - rather Indicated Air Speed (IAS) as displayed in the HUD. The pitch ladder may be cycled on or off by pressing the middle button, labeled 'PL'.

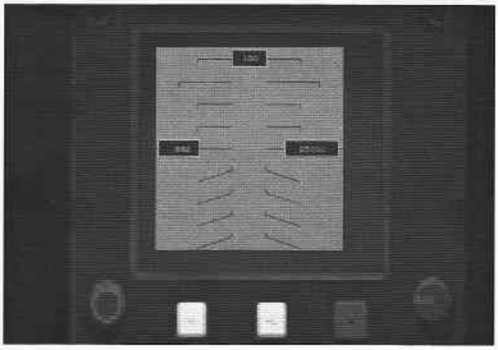


Figure 13

This unit can also be used to display and control the autopilot system by pressing the right-hand button, labeled 'A'. To return the unit to Artificial Horizon mode, press the left-hand button, marked 'H'.

Part VII Using Shoot Lists

Shoot lists provide the F-22 with extremely powerful tools that enhance weapons deployment. By allowing the pilot to select multiple targets and formulate an attack plan in advance, attacks can be executed with speed and precision. Stealth can be maintained for as long as possible thus minimizing exposure to enemy sensors, and consequently, enemy weapons systems. When you are ready to attack, you are able to strike quickly, and effectively, then vanish from enemy screens.

Targets must be within approximately 60 miles of your aircraft in order to be placed on the shoot list. The Shoot list can be built either automatically by the F-22's avionics, or created manually by selecting targets visually or from any of the three main MFDs.

To build a shoot list, you must first select which weapon will be used. All Air-to-Air missiles and all guided Air-to-Ground weapons require that the target be placed in the shoot list before you can lock on to, track or engage it. Pressing the F9 key will automatically place up to 10 enemy targets on the shoot list. Targets are prioritized primarily on the basis of distance. The closest target is placed at the top of the list (number 1) and other targets are lined up below it. However, if several targets are relatively equidistant from your aircraft, those closest to the centre of the HUD are given the highest priorities. Pressing the T key again will rebuild a shoot list using a new set of priorities if the disposition of the enemy changes. Pressing the U key will clear the current shoot list altogether.

You can build a shoot list manually in two ways; either by clicking the mouse cursor on a target in one of the MFDs, or by pressing the S key while you have a target visually padlocked. As new targets are added, they are placed at the head of the list and displace other targets down one position. If the list is full, the target with the lowest priority will be dropped to maintain the ten-target limit. Once again, pressing the U key will clear the current shoot list allowing you to start over from scratch.

On the MFDs, clicking on a target already in the shoot list will advance it to the top of the list, reordering all other targets as needed.

Clicking on it a second time will remove it from the list. Pressing the S key, either once or twice, while viewing a target in padlock will have the same effects. Pressing the C key scrolls forward through the shoot list, selecting the next target as the item of interest for the current weapon, as well as the padlock viewing system. Pressing the X key will scroll backwards through the list.

As viewed on the MFDs, the current target's icon will appear inside a solid white circle. Other targets' icons will be circumscribed inside a hollow white circle. Targets that are not being tracked on the shoot list appear as normal icons. Viewed through the HUD, targets on the shoot list appear as solid icons. The current target will appear surrounded by a circular outline. Finally, targets not on the shoot list appear as dashed icons in the HUD.

Numbered carets appear on both the TSD and Attack displays when targets have been place on the shoot list. The currently selected target's caret is shown filled, while all others appear as outlines. On the TSD, the carets appear in a single, ordered column along the right-hand side of the screen. You can easily determine where the current target of interest is placed in the shoot list – near the top, or near the bottom – by checking this display. On the Attack MFD, two sets or carets are displayed, on either side of the screen. Those along the left-hand side lay alongside the altitude scale and correspond to the target's altitude above sea level. Those along the right-hand side of the MFD are placed along the range bar and reflect the relative distance of each target from the F-22, as well as their position relative to the maximum effective range of the selected weapon.

Pressing the M key will add the currently padlocked target to your wingman's shoot list. You can also use the radio to transmit this order to your wingman by pressing the TAB, 3 and 1 keys in succession. This is a more effective way of assigning a specific target to your wingman than generically ordering him to 'engage bandit' or 'engage hostile.' These latter commands allow him to select targets on his own, and may not achieve the desired results. A more complete discussion of wingman tactics and techniques is covered in Chapter 6, 'A2A Combat'.

Part VIII Overview of the Heads Up Display

Since World War II, all combat aircraft have featured some form of HUD (Heads Up Display). The technology has come a long way since those early days when a primitive gunsight was the only item presented on the HUD. Although in today's modern, more computerized combat aircraft, the quantity and quality of information presented to the pilot on the HUD has increased many-fold, the basic display technology remains the same.

The HUD consists of an angled plate of glass mounted above the instrument panel between the pilot and the forward windscreen. Information is projected on the glass, allowing the pilot to scan flight data, weapons targeting information and other items of importance without having to glance down at his instruments. The one problem with a HUD system is that although the pilot need not look down to obtain flight information, he can only see the information if he is facing forward.

The HMD (Helmet Mounted Display) is a much more recent development and is available on only the most technologically advanced aircraft. The HMD allows the pilot to continue to see flight information regardless of where his gaze is focused. Moreover, when coupled with advanced weapon systems, the HMD can even allow the pilot to designate targets simply by looking at them.

The pilot of a combat aircraft equipped with HMD technology has a tremendous tactical advantage over enemies not equally outfitted. Utilizing the HMD, he has the ability to track and engage targets over a much broader section of the sky than might otherwise be possible - capabilities that are extremely valuable in a close combat environment.

In F-22 ADF/TAW, the HMD is active any time the view is not directed either forwards through the HUD, or at one of the other instrument displays. The true capabilities of the real F-22's HMD remains under a cloak of secrecy. In F-22 ADF/TAW, the HMD and HUD have been modeled to provide nearly identical displays. While this may prove unrealistic, it does make discussion of the features in the HUD and HMD less complicated. In the pursuit of simplicity, we will, from this point forward, use the term HUD to mean both the HUD and HMD unless indicated otherwise.

The HUD operates in five different modes: Air-to-Air (A2A), Air-to-Ground (A2G), navigational, instrument landing and refueling modes. The HUD will automatically switch to the appropriate mode for the currently selected weapon, or the current task at hand. You can cycle through the HUD modes manually by pressing the **H** key on the keyboard.

The colour of the HUD/HMD displays can be cycled by pressing the **SHIFT - H** keys. This is useful for improving visibility against a variety of backgrounds. Pressing the **J** key reduces the amount of information displayed on the HUD/HMD - 'declutters' the view - and is useful for focusing on an individual target, especially in Air-to-Ground attacks. The following items are removed from the HUD when this option is selected: the Flight Path Marker, the Terrain Following Box, the radio frequency indicator, the EMCON level indicator, and all target icons except the currently selected target.

Although not truly part of the HUD, small, 'mini-MFDs' can be placed in the corners of your screen by pressing the **ALT-Q** key on the keyboard. A copy of the Defence MFD occupies the lower left-hand corner, and a copy of the TSD appears in the lower right. Doing this helps compensate for the fact that, unlike real world pilots who can quickly glance at the instrument panel, computer pilots must change screens to do view the different displays. The mini-MFDs are active by default in the full-screen, forward views. Pressing **ALT-Q** toggles between this configuration, displaying the mini-MFDs in both the full screen and HUD/HMD views, and no display of the mini-MFDs at all. The number at the upper right of either mini-MFD is the currently displayed maximum range.

Each HUD mode presents a slightly different mix of information designed to meet the needs of the task at hand. However, many items are common to all five HUD modes. Figure 14 illustrates most of the common HUD features. We will look at these common features first and then note the differences for each mode in turn.

Common HUD and HMD Symbology

Airbrake

The words 'ABK ON' or 'ABK OFF' will appear in the data block located in the lower right-hand corner of the HUD to indicate the status of the airbrake. In addition, a flashing 'V' will appear above the flight path marker whenever the brakes are extended.

Airspeed and Mach number

The current airspeed is displayed in a small box on the left-hand side of the HUD. The value shown is 'indicated airspeed' as opposed to 'true airspeed'. The airspeed as a percentage of the speed of sound, or

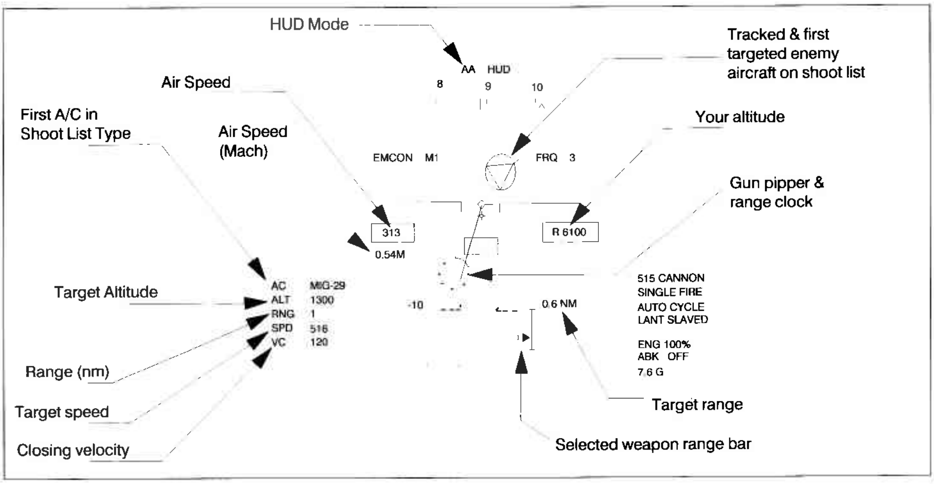


Figure 14

Mach number, is displayed below the airspeed box. For example, '0.50M' indicates that you are travelling at one-half the speed of sound, '1.50M' represents one and one-half the speed of sound, etc..

Altimeter

Altitude is displayed in a small box on the right-hand side of the HUD. Barometric altitude (above sea level) is displayed when the aircraft is greater than 5,000 feet above the surrounding terrain. At altitudes of less than 5,000 feet above ground level, the display is Radar Altitude. The letter 'R' appears in front of the numeric value when radar altitude is being displayed.

Compass Ribbon

The compass ribbon scrolls across the top of the HUD and is subdivided in 5-degree increments. Numeric compass headings are marked at 10-degree increments along the ribbon. A vertical 'tick mark' below the compass ribbon indicates the aircraft's current heading. Two waypoint markers are present. An inverted 'V' caret appears below the compass ribbon and indicates the direct heading towards the next waypoint, independent of the preprogrammed route. A 'triple tick mark' above the compass ribbon indicates the direction you must steer in order to intersect the preprogrammed waypoint route. If the two markers are lined up with the heading 'tick', the aircraft is following the programmed route. If the waypoint caret is all the way to one side of the compass ribbon, turn in that direction until you are back on the proper heading.

EMCON Status Indicator

Located in the upper left-hand corner of the HUD, the word 'EMCON' appears followed by an alphanumeric indication of the

current EMCON Level. For example, 'A4' indicates auto EMCON Level 4, 'M1' indicates manual EMCON Level 1, etc..

Engine Thrust Level

Thrust level is displayed as a percentage of 'Full Military Power' in the lower right-hand corner of the HUD. Values range from 0 percent (engines off), through 100 percent (full military power), to 140 percent (full afterburner).

Flight Path Marker and Centerline Indicator

A small cross with a circle marks the centre of the HUD and corresponds to the centerline of the F-22 – where the nose is pointed. The flight path marker, or 'velocity vector', is displayed as a small, stylized aircraft icon which represents the current direction of the F-22's flight – where the aircraft is really going. The direction and degree of displacement of the flight path marker away from the centerline is an indication of what Angle of Attack and/or yaw the aircraft is experiencing. If the flight path marker is shifted to one side of the centerline, the aircraft is flying slightly sideways – crabbing. If the flight path marker is above or below the centerline, the aircraft is experiencing negative (above the centerline) AoA, or positive (below the centerline) AoA.

G-Force Indicator

The current load factor, in positive or negative 'Gs', is displayed as in the lower right-hand corner.

Ground Proximity Warning

If the the F-22's flight path makes collision with the ground or other terrain obstacles imminent, the words 'PULL UP' will flash in the centre of the HUD. This visual warning is accompanied by an audible cue from 'Bitching Betty'.

Pitch Ladder

The pitch ladder is a series of paired lines drawn across the HUD which remain parallel to the horizon, providing you with aircraft pitch and bank orientation cues. A long pair of lines represents the horizon itself. Shorter pairs of lines appear at 10-degree increments above and below the horizon lines. Pitch lines appear solid above the horizon and as dashed lines below the horizon. Small 'hooks' on the ends of the pitch lines point to the horizon.

Radio Frequency Indicator

The currently selected radio frequency is displayed in the upper right-hand corner of the HUD. For example, 'FRQ 1' indicates radio frequency 1, 'FRQ 2' represents frequency 2, and so forth.

Terrain Following Box

The avionics combines stored digital maps, Ground Positioning Satellite (GPS) location data and the radar altimeter to calculate the flight path that will provide a minimum of 200 feet clearance over the surrounding terrain. Displayed as a small rectangle on the HUD, you need only to keep the flight path marker within the 'box' in order to maintain a safe low-level flight profile.

Waypoint 'X'

An 'X' symbol is drawn to mark the point on the ground that corresponds to the next programmed waypoint.

Common HUD Target Symbology

The target symbology displayed in the HUD is nearly identical to that presented on the Situation, Attack and Defence MFDs. However, since the HUD is a monochrome display, no colour-coding is provided to differentiate the allegiance of targets. You should pay close attention to the target data block presented in the lower left-hand corner of the HUD to positively identify targets prior to weapons release in order to avoid firing on allied forces.

The pentagons, upright crosses and inverted 'T's' used to designate ground based radar sites, SAMs, AAA, ground mobiles, and ships in the HUD are the same as their MFD counterparts. Likewise, enemy, neutral and unidentified airborne targets are displayed as triangles. Allied airborne targets are the only ones displayed differently - as squares.

A short line extending from the aircraft icon indicates the target's current aspect angle with respect to the F-22. If the line is pointing up, the target is flying away from you. Conversely, if the line is pointing down, the target is towards you. When the line points to the right or left, the target is flying at right angles to your line of sight. Aspect angle is critically important in determining optimal weapons release conditions. This topic is covered in greater detail in the 'Target Aspect Angle' section of Chapter 5, 'A2A Weapons'.

Targets that are being tracked by the F-22's avionics but not yet assigned to a shoot list are drawn with dashed outlines. Targets that have been assigned to the shoot list are shown as solid outlines. A circle will surround the currently selected target.

If the game has been set to either easy or medium difficulty level, a small letter 'T' will appear above and to the left of a target's icon to signify that it is a primary mission target. At the hard difficulty level, no such indication appears and you will have to identify primary mission targets by type alone as directed in the mission briefing.

When more than one target of a given type occupies the same space on the HUD, a numeric indication of the number of targets will appear above and to the right of the icon. This minimizes the amount of clutter that would be generated by displaying multiple icons in the HUD and makes it easy to determine how many enemies you will be dealing with.

AIR-TO-AIR (A2A) HUD SYMBOLOGY

When the Air-to-Air HUD mode is selected (Figure 15), several new items appear in the HUD which relate to the tasks of target identification, tracking, and weapons delivery. Chapter 5, 'A2A Weapons' provides additional information on how to use these features for weapons deployment.

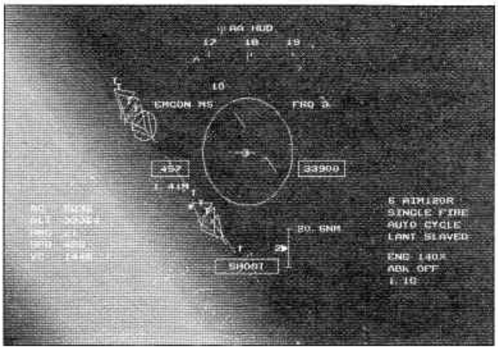


Figure 15

Diamond X

This is a crosshatched diamond symbol that appears whenever the current target is not visible in the HUD, but is still being tracked by the F-22's avionics and sensors. Manoeuvring the aircraft in the direction of the Diamond X should bring the target back into view. If the sensors lose contact with the target, the Diamond X will disappear. The Diamond X is absent from the HMD as the view through the HMD is usually directed at the current target.

Infra-Red Missile Seeker Box

Although the avionics will direct the missile attention to the selected target, IR missiles must lock on to a heat signature prior to launch if they are to hit their target. The broken box symbol represents the position of the missile's seeker head. When this indicator is flashing over a target icon, the missile has a positive lock. When IR missiles are carried externally the seeker head is usually already on the target by the time it is in range. In cases where an internal IR missile is being fired, the missile may need a moment to 'sniff the air' before launching. Pressing the trigger once will force the missile into the slipstream and allow it to acquire the target. Press the trigger a second time to release the missile once the IR seeker box has centred on the target and is flashing on and off.

Missile Steering Cue

A small square will appear in the HUD whenever the Aiming Reticle is active. This symbol indicates the point to which you should steer the nose of F-22 in order to provide the missile with the optimal amount of 'lead' necessary to intercept the currently selected target.

Predictor Gunsight

The gunsight consists of a circular reticle and a predictor line connecting the centre of the reticle, or 'pipper', to the centre of the HUD. The reticle doubles as a range indicator, changing from a solid to a dotted line in a counter-clockwise fashion as F-22 moves closer to the target. Placing the pipper over the target once it is in range provides a good chance of scoring a hit. The line, or 'snake' as it called due to the convolutions it makes, represents the predicted path of the shells.

Probability of Kill (PK) Indicator Circle

The PK Indicator circle appears when the currently selected target is within the effective engagement range of your A2A missiles. This is a graphical indication of the level of certainty that your missile will strike the target. The PK Indicator Circle will grow or shrink based on the location of the target with regards to the missile's engagement envelope.

Range To Target Bar

When one or more targets are placed in the shoot list, a range bar will appear below the altimeter. The lines at the top and bottom of bar represents the maximum and minimum effective ranges for the currently selected weapon. A triangular caret will appear to the left of the range bar. The number alongside the caret indicates the target's position in the shoot list. The location of caret relative to the range bar represents the target's range relative to the weapon's firing envelope. The actual range to target is given to the right of the range bar. When the caret points to a spot between the top and bottom of the bar, the target is within the current weapon's engagement envelope.

Shoot Cue

When the release parameters for the selected weapon are met, a text box will flash in the HUD with the word 'SHOOT'.

Target Data Block

Five lines of information are displayed in the lower left-hand corner of the A2A HUD whenever a target is selected. The first line, labeled 'AC', provides identification of the target type. The 'ALT', 'RNG' and 'SPD' lines display the target's current altitude, range and speed respectively. The bottom line, labeled 'VC', displays the closure rate in knots between the F-22 and the target. A positive closure rate indicates that you are closing the gap between yourself and the target. A negative rate means the distance to the target is increasing.

Weapons Data Block

These five lines of text appear on the right-hand side of the HUD in order to provide information about the type of weapon currently selected. The first line, labeled 'WEP', identifies the currently selected weapon type: Cannon, AIM-9X infrared missile, AIM-120C or AIM-120R radar guided missile. The second line, labeled 'WEP NO', indicates the number of missiles of this type remaining or the number of gun rounds remaining in the case of the cannon. The third line displays the current fire mode - single, ripple or salvo - as well as the number of weapons to be released when the trigger is depressed. The fourth line indicates whether the shoot list is set to automatic or manual cycling mode. The final line indicates the current LANTIRN mode - slaved or free.

Weapons 'Safe' Indicator

When radar guided missiles are selected, the words 'ARM OFF' will appear in the upper left-hand corner, if the current EMCON Level is not 3 or higher to indicate that these missiles cannot be fired.

AIR-TO-GROUND (A2G) HUD SYMBOLOGY

Whenever A2G weapons are selected, the HUD symbology changes to display navigational information and weapons release cues. There are three different sub-modes of the A2G HUD, depending on the type of weapon currently selected. These are Continuously Computed Impact Point (CCIP) mode, guided weapons mode, and unguided weapons modes. Each mode features a different targeting sight.

This section will provide an introduction to the different A2G sub-modes and an overview of the different targeting sights. A more detailed guide to weapons selection, targeting and delivery will be given in the Chapter 7, 'A2G Combat'.

Waypoint Data Block

Three lines of data about the current waypoint appear on the right-hand side of the HUD underneath the Altimeter box. The first line indicates the currently selected waypoint number. The second line shows the distance to the current waypoint in nautical miles. The third line displays a 'Time To Waypoint' countdown timer and represents the time required to reach the current waypoint based on the current airspeed.

Weapons Data Block

The A2G Weapons Data Block is identical in form and location to the one described in the A2A section.

A2G TARGETING SIGHTS

Continuously Computed Impact Point (CCIP) Sight

If freefall, retarded or cluster munitions are selected, the CCIP sight will be displayed on the HUD. A fall line drawn is drawn through the HUD and indicates the path the weapon will take when released. The fall line passes through a semi-circular Angle of Bank indicator with tick marks at 10-degree intervals. The CCIP marker is a short horizontal line crossing the fall line and indicates the point on the ground where the bomb will impact if it is released 'right now.' In order to score a hit, release the bomb when the intersection between the fall line and the CCIP marker is directly over the target. Figure 16 shows the fall line and CCIP marker passing through the factory building ahead.

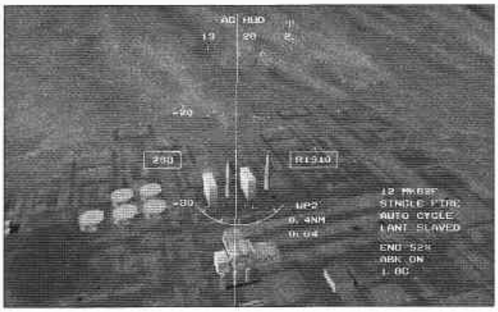


Figure 16

Guided Munitions Sight

When guided weapons such as the AGM-88 HARM, JDAM or Maverick missiles are selected and one or more ground targets have been placed in the shoot list, the HUD, the Guided Munitions sight will appear. A range bar and caret, similar in appearance and function to those seen in the A2A sight will appear below the altimeter box. When the caret points to a spot between the top and bottom of the bar, the target is within engagement range. Figure 17 shows an AGM-88 HARM missile targeted on the SAM site visible at the left-hand side of the HUD.

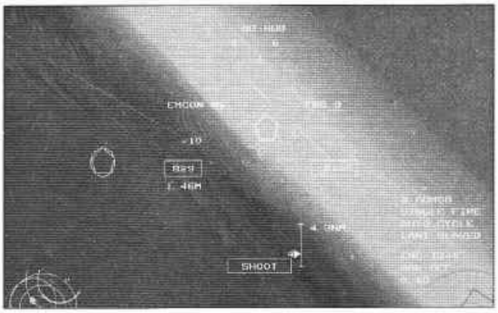


Figure 17

Unguided Munitions Sight

When the cannon or LAU-68 rockets are selected, a predictor gunsight and range circle will appear in the HUD. Unlike the A2A gunsight, no 'snake' is depicted. The pipper in the centre of the range circle represents the predicted point of impact for the weapon. Figure 18 shows three target vehicles superimposed with upright cross icons. The first vehicle is the currently selected target, as

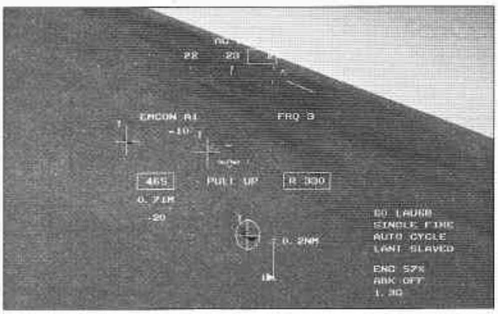


Figure 18

indicated by the circle surrounding the target icon. The gunsight is visible just above the flight path marker

NAVIGATIONAL HUD SYMBOLOGY

When the navigational HUD mode is activated, several new items appear in addition to the standard waypoint data block which aid in following the programmed route precisely. Figure 19 shows the view through the HUD when this mode is selected. The Navigational HUD provides you with waypoint steering and fuel status information.

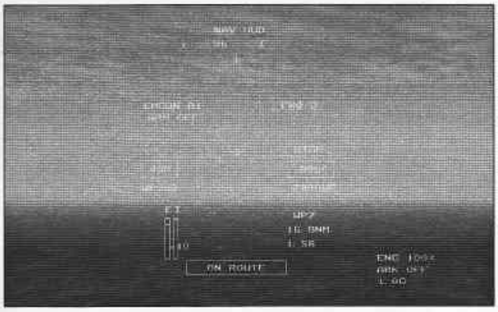


Figure 19

Fuel Status Bars

A pair of bars labeled 'E' and 'I' display the amount of fuel remaining in the external and internal fuel tanks.

On Route Indicator

A text box indicating 'ON ROUTE' will appear at the bottom of the HUD. Although this item would be useful if it indicated that the F-22 was within programmed route parameters, it does not appear to function in the current version of F-22 ADF/TAW.

Waypoint Altitude Indicators

Two items appear above and below the altimeter box to show what the programmed altitude is for the next waypoint. The desired altitude is displayed under the altimeter box along with the letters 'WP'. The words 'HIGH' or 'LOW' will appear above the altimeter box to indicate what your current altitude is compared to the expected altitude.

Waypoint Speed Indicator

The programmed airspeed for the current leg of the waypoint route is displayed below the airspeed box, preceded by the letters 'WP' to indicate waypoint speed.

Weapons 'Safe' Indicator

When the F-22 is in navigational HUD mode, all weapons are disabled - 'safed'. The words 'ARM OFF' will appear in the upper left-hand corner, under the EMCON Level, to indicate this condition.

INSTRUMENT LANDING HUD SYMBOLOGY

When the Instrument Landing HUD (Figure 20) is activated, the steering cues on the compass ribbon will indicate the direction you must fly to reach the airfield programmed on your waypoint route. A time and distance display replace the waypoint data block to show how far you are from the base and how long it will take to reach it at your current speed.

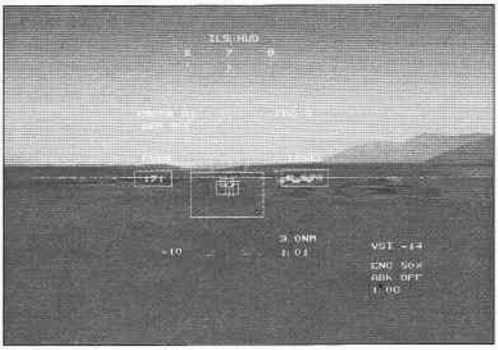


Figure 20

Weapons are 'safed' in Instrument Landing mode and the 'ARM OFF' indication will appear in the upper left-hand corner of the HUD.

New items appear which will assist you in locating and following the landing glide slope.

Command Flight Path Display (CFPD)

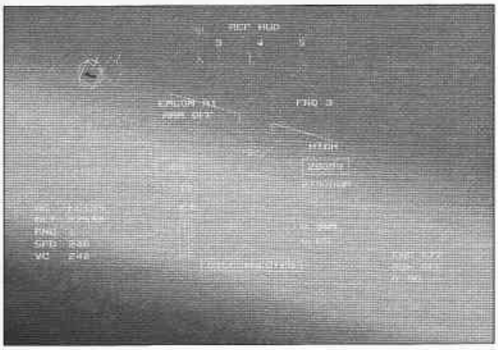


Figure 21

On runways where an Instrument Landing System (ILS) is active, the CFPD will appear when you are within 15 miles of the airfield. The CFPD provides a 'corridor of boxes', outlining the glide slope and leading to the touchdown point on the active runway. By manoeuvring your aircraft so that the flight path marker passes through the boxes you will be guided to a perfect approach. Only one runway at any time will feature an active CFPD. The airfield will activate the CFPD for the runway to which you have been directed. The CFPD may be turned on and off by toggling the 'IL' button on the Systems Status MFD.

Glide Slope Cues

Text cues will appear above the airspeed and altitude boxes to indicate whether your approach is too 'FAST' or too 'SLOW', and whether you are 'HIGH' or 'LOW' with respect to the glide slope. When you are precisely on track, both displays will read 'EVEN'.

Landing Gear Lock Indicators

When the landing gear is down and locked, three small circles will appear on the HUD above the centre point.

Vertical Speed Indicator (VSI)

The Vertical Speed Indicator (VSI) is located above the Engine Thrust

Indicator. This instrument displays your climb or descent rate in feet per second.

REFUELING HUD SYMBOLOGY

The Refueling HUD displays information that enables you to locate and rendezvous with an airborne tanker. The compass ribbon steering cues will direct you to the prearranged tanker or an alternate as directed by AWACS controllers. The tanker's distance from the F-22 and the time to intercept is displayed beneath the altimeter box.

The avionics will 'lock on' to the tanker and display a 'friendly' airborne target box in the HUD to indicate the tanker's location. The Target Data Block in the lower left-hand corner of the HUD will display the tanker's current altitude, range, speed and the relative closure rate between the tanker and the F-22. Figure 21 illustrates the view seen through this HUD mode. The tanker is seen as a locked target ahead and slightly above and to the left of the F-22's flight path.

The words 'HIGH', 'LOW' or 'LEVEL' will appear above the altimeter box providing you with a way to quickly determine whether you are at the proper contact altitude.

A text box at the bottom of the HUD displays 'DISCONNECTED' until contact is made with the refueling boom. Once contact is made, the text box will change to 'CONNECTED', and then to 'FUEL IN' once fuel is flowing from the tanker to your aircraft.

Fuel gauges for internal and external fuel tanks are displayed beneath the airspeed box.

Weapons are 'safed' in Refueling mode and the 'ARM OFF' indication will appear in the upper left-hand corner of the HUD.

Part IX Autopilot

The autopilot can be likened to an intelligent form of the simple 'cruise control' that you may have on your automobile. However, unlike its earthbound counterpart, the autopilot can do much more than simply maintain your speed. Most modern autopilot systems are capable of holding an aircraft in level flight at a given heading, altitude and speed, or following a pre-programmed course complete with heading, speed and altitude changes. The more advanced systems can automate additional tasks such as following a glide path for landings. The F-22, as modeled in ADF, is equipped with an extremely sophisticated autopilot that can accomplish all these tasks and more. Taxiing and takeoff, terrain avoidance, refueling operations as well as target tracking and pursuit are all within the capabilities of the F22's autopilot.

Given the complicated nature of the strategic tasks you will be required to perform, you will rely frequently on the autopilot to mind the task of flying the airplane while you concentrate on target selection and weapons deployment. Mastery of the various modes and options available to you is essential to achieving your mission goals successfully.

There are seven main autopilot modes: waypoint, heading, target track, speed hold, takeoff, landing and refueling. Each mode has a variety of sub-mode choices and options. This section will familiarize you with these modes and enable you to use the autopilot effectively.

Regardless of what mode you select, there is one limitation to the autopilot of which you should be aware. The autopilot will NOT advance the throttle beyond 100 percent military thrust, under ANY circumstances. If you dial in a speed that requires afterburner, you will not attain it. If you use the autopilot but need to get to your destination quickly, consider modifying your settings so that you fly at a higher altitude.

Displaying and Activating the Autopilot System

The autopilot controls may be displayed on any of the four main MFDs as well as the Artificial Horizon display. Using the mouse

cursor to press the 'A' button on any of these displays will bring up the autopilot control screen.

The desired autopilot mode is selected by clicking on the appropriate menu item displayed at the top of the control screen with the mouse cursor. Depending on the selected mode, additional information and options will appear below these buttons. Items that have '+' or '-' buttons alongside them are adjustable. Clicking on these will increment or decrement the selected function setting respectively. The button marked 'Current', alongside many of the functions, allows you to transfer the current values for that function to the autopilot. This makes holding your current speed, heading or altitude a simple matter of pressing one button per function rather than having to adjust each one individually to the proper setting. Items which do not have either '+', '-', or 'Current' buttons cannot be changed and are merely presented for your information.

The autopilot can be activated either by pressing the A key on the keyboard, or by clicking on the large control button displayed at the bottom of the MFD. When activated, the button will change to display 'Auto' against a red background. When the autopilot is inactive, this button will display 'Manual' against a blue background.

Waypoint Autopilot Mode

Waypoint mode directs the autopilot to fly towards the currently active waypoint. As you reach each waypoint, the aircraft will continue along the current pre-programmed route, using the altitude and airspeed settings stored in the avionics computers.

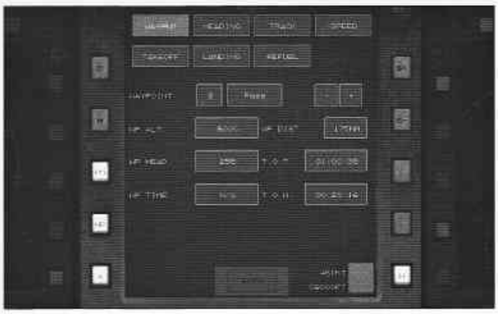


Figure 22

In waypoint mode (Figure 22), the autopilot displays the altitude, heading, speed, distance, timing information, number and tasking orders for the currently selected waypoint. The active waypoint – may be changed by clicking on the '+' or '-' buttons. In waypoint mode, the autopilot will fly the aircraft using the altitude setting that has been stored for the active waypoint. If you wish to adjust this setting, you will need to use the waypoint editor available on the TSD. There is no way to change the pre-programmed waypoint speed setting.

As we have already noted, this mode will automatically advance to the next waypoint in turn, allowing you to follow your route precisely. However, the tactical situation may require that you deviate from the planned route in order to avoid threats. Of course, you can move or edit waypoints using the editor, however this is cumbersome and prone to error. When you need flexibility, heading autopilot mode offers the highest degree of freedom to control over your flight path.

Heading Autopilot Mode

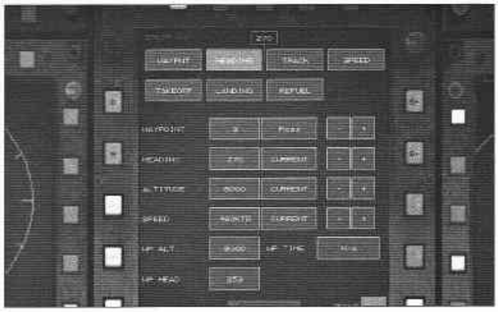


Figure 23

Heading autopilot mode (Figure 23) is the most versatile mode available to you in F-22 ADF/TAW. In this mode, you can freely adjust your heading, speed and altitude to accommodate the situation at hand. The currently active waypoint is displayed, along with tasking orders, heading, altitude, airspeed and timing information.

As in waypoint mode, the currently active waypoint can changed by clicking on the '+' or '-' buttons alongside the tasking order display. This has no effect on where the autopilot directs your aircraft, but it does allow you to view the tasking orders for specific waypoints. Three new items are now available: heading, altitude and speed. To the right of each item are buttons marked 'Current', '+' and '-'. Clicking on 'Current' transfers your current heading, altitude and/or speed to the autopilot. This provides you with a quick and easy way to set the desired parameters. Simply hand fly the aircraft to achieve the desired condition then select 'Current' in order to instruct the autopilot to hold them. If you wish to make fine adjustment to these settings after the autopilot is engaged, use the '+' or '-' buttonsas needed.

Target Tracking Autopilot Mode

Target tracking mode (Figure 24) will manoeuvre your F-22 so as to keep the nose pointed directly at the currently selected target. If you do not have a target selected, this mode will not engage.

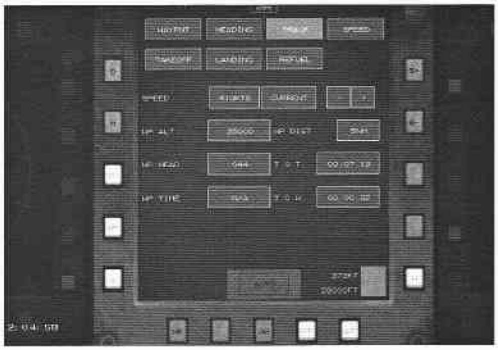


Figure 24

The only adjustable option in target tracking mode is your airspeed. Altitude and heading are determined by the position of the target relative to your aircraft. By varying the speed, you can control your closure rate, and distance from the target. Tracking mode is most useful for station keeping in a trailing formation. This works extremely well when you are flying cooperatively with other players and is useful for maintaining formation integrity over long distances. Although you can use tracking mode to maintain position behind a group of other aircraft during escort missions, this is tactically not the best place from which to shepherd your flock.

Perhaps the best use for tracking mode may be when you are preparing to refuel, assuming you intend to complete the manoeuvre manually. You can use tracking mode to fly the aircraft into pre-contact position behind the tanker, taking control you are ready to hook up. You will need to lose a bit of altitude before you can hook up as tracking mode will leave you at co-altitude with tanker. You will

also have to watch your throttle setting carefully when you release the autopilot to ensure that you do not fly right into the tanker's tail. Chapter 3, 'Learning to Fly' contains a rundown on refueling procedures. Of course, if you wish to refuel automatically, then simply use the refueling autopilot mode, which will be covered shortly.

Tracking mode has limited usefulness in offensive situations, although one exception may be where you wish to attack a group of enemy fighters from long range. Since it flies a pure pursuit path, tracking mode will put you in a reasonable position from which to launch your long-range missiles. Coupled with auto target cycling and ripple fire, this can enable you to attack multiple targets almost automatically since your aircraft will position itself to take the next shot in turn as each target is engaged. Do not be tempted to use this mode in a close range dogfight against multiple bandits, however. Since the autopilot cannot anticipate what manoeuvres may need to be applied next, nor will it engage the afterburners, it will tend to lag well behind on the power curve.

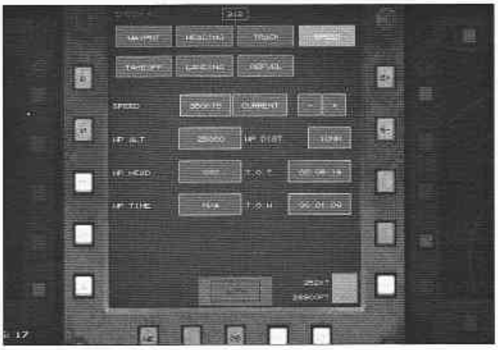


Figure 25

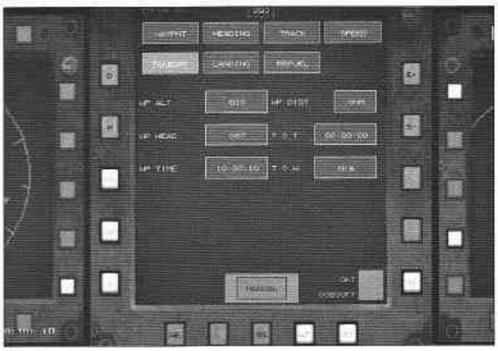


Figure 26

Speed Autopilot Mode

In speed autopilot mode (Figure 25), you are free to manoeuvre the aircraft as you wish. The autopilot will do its best to maintain a constant airspeed, manipulating the throttle or applying the airbrakes as necessary. You can either pre-set the desired speed with the '+' or '-' buttons, or click on 'Current' to have the autopilot hold your current airspeed.

You may find this mode useful while flying landing approaches, or for holding formation near other aircraft while maintaining the freedom to manoeuvre. However, because the autopilot cannot anticipate what manoeuvres you are about to perform, it tends to lag behind if you execute hard turns or sharp changes in altitude. In addition, since the autopilot will NOT engage afterburners, speed loss may rapidly become extreme if you execute manoeuvres that bleed off a lot of speed.

Take Off and Landing Autopilot Modes

As we noted at the beginning of this section, the autopilot in F-22 ADF/TAW is sophisticated enough to handle the job of taxiing to the runway, taking off and landing. There are no adjustable parameters for either of these modes as these tasks, while they involve a series of

complicated manoeuvres, are essentially self contained. Figures 26 and 27 show take off and landing autopilot modes respectively.

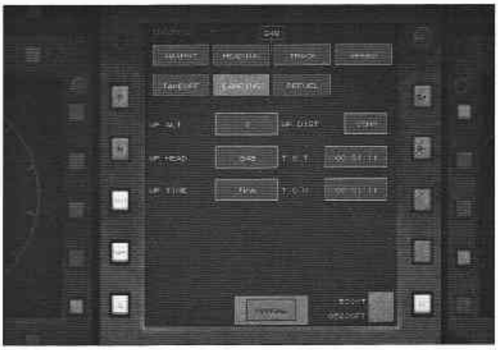


Figure 27

In order for either of these modes to operate, you must have obtained clearance from the tower for the desired action. For takeoffs, you must have been cleared to taxi. For landings, you must have been cleared to fly your approach. Once you have been given clearance, acknowledge the tower by pressing the Y key. Then simply select the appropriate mode, engage the autopilot, sit back and enjoy the view.

As noted previously, take off autopilot can relieve you of the tasks of taxiing to the active runway and allow you to use the time to set up your preflight preferences on the MFDs, etc. If you are in a real hurry to take off, a more effective option may be to use the 'time skip' - 'Shift S' feature to teleport yourself to the line up position.

Landing is a skill that, while it may be difficult to perfect, is a source of extreme satisfaction when performed correctly. As a consequence, using the landing autopilot mode is, at best, a procedure that will rob you of this pleasure and, at worst, an outright cheat. We will walk you through the details of how to achieve a perfect touchdown in Chapter 3, 'Learning to Fly'. However, the landing autopilot has a place in the larger scheme of things. One possible application may be in situations where you have incurred damage to the airplane that may complicate the execution of a safe landing. Assuming the damage is not so severe as to render the autopilot inoperable, using the autopilot is preferable to ending an otherwise successful mission as a charred wreck littering your home airbase. Given the choice, take the safe route. However, take the time to learn how to land your aircraft manually. Otherwise, you will have no options available to you if you succeed in limping home in a damaged aircraft where the autopilot has failed.

One final note about take off and landing modes. While the original F-22 ADF release allowed you to taxi (unrealistically) through other aircraft if your speed was low, this is no longer the case with the release of F-22 Total Air War your aircraft will now be damaged or destroyed if you taxi into other aircraft at ANY speeds, (unless you have applied the TAW patch). Although these autopilot modes will guide your aircraft appropriately, they will not avoid collisions with others. Be prepared to disengage the autopilot and retake manual control if a collision is imminent.

Refueling Autopilot Mode

Refueling is arguably the most grueling exercise in precision flying you will be called upon to perform in F-22 ADF/TAW. Much more

than takeoff or landings, refueling is something that you will need to practice long and hard to perfect. We will give you some pointers on refueling in Chapter 3, 'Learning to Fly'. However, this is one procedure where you should not be ashamed to allow the autopilot to complete the task for you. Sooner or later, the situation will arise where you arrive at the tanker with nothing but fumes in your tanks. You may not have the luxury of taking the time to line yourself up manually. Moreover, Murphy's Law states that the tanker will bank into a turn on its circuit at the moment you most need the fuel! By all means, learn how to perform this task manually. However, do not be afraid to let 'Otto' handle the stick and throttle if time is of the essence.

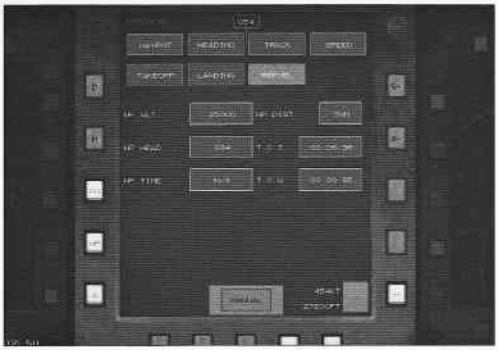


Figure 28

In order to use the refueling mode, the refueling mode HUD should be active, the autopilot must be set in refueling mode (Figure 28) and you must have requested and received clearance to refuel. Once you affirm that your weapons and nose are 'cold' by pressing the Y key on the keyboard, engage the autopilot and watch as your F-22 hooks up to quench its thirst.

Auto Recovery

Auto recovery utilizes the autopilot to restore the aircraft to level flight – essentially, a 'which way is up' button – and is engaged by pressing the D key. Auto recovery is of limited use in F-22 ADF as it is insensitive to terrain obstructions and will blindly fly you, straight and level, into a mountainside.

Putting it altogether - using the Avionics

You should, by now, be familiar with the components of the F-22's avionics suite. We will run through a simple A2A intercept mission in order to demonstrate some of the concepts covered in this chapter. For this mission, we will fly the 'Using the IRST' mission in the Simulator Air-to-Air Tactics section of F-22 ADF.

This mission calls for you to fly a solo intercept against two Su-30 strike aircraft, reported inbound on a low-level attack run against allied targets. The mission begins in the air. You are flying Combat Air Patrol over southern Egypt, heading southeast towards a mesa, just visible in the distance, about 20 miles away. Intermittent radar contacts show a pair of unidentified aircraft heading northwest, approaching the mesa from the opposite side at low level. Your mission is to first identify the aircraft, then shoot them down if they are the Su-30s.

First, get your 'office' in order. Since this is to be a stealthy intercept, switch to Manual EMCON Level 1 – this ensures that all active sensors are off-line. Next, bring up the map view on the TSD. You will want to utilize whatever terrain features are available to us before determining what our course of action should be. Zoom in until you can clearly see the mesa and the surrounding terrain.

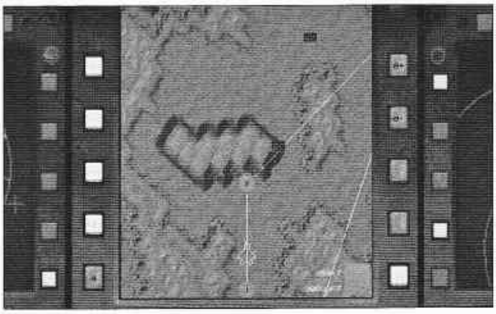


Figure 29

Figure 29 shows that the programmed waypoint route veers off to the south along the right-hand side of the mesa. The mesa itself is clearly visible, as is lower, eroded terrain to the east, wrapping around the mesa on the left-hand side. Since the flight path of the inbound aircraft is expected to lead them more towards the southern end of the mesa, swing around the northern end of the mesa. This will allow you to approach undetected from behind the mesa, and if necessary, make use of the low terrain found to the north and east of the mesa for further concealment.

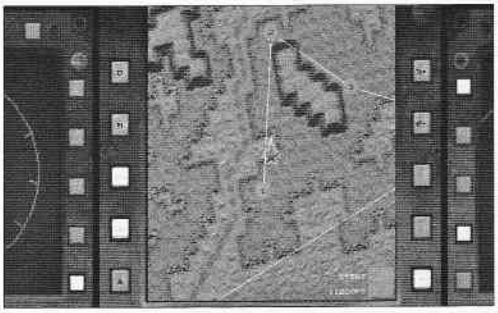


Figure 30

Engage the autopilot in waypoint mode. This will head you directly towards the mesa for now. Next, activate the waypoint editor, and set up a route that swings you around the northern side of the mesa. First, drag waypoint 2 around to the northwest corner of the mesa. Next, click on the blue box between waypoints 2 and 3, adding a new waypoint near the southwest corner of the mesa – about where you think the intercept will take place. Figure 30 illustrates what this revised route might look like. Once the route is set, disengage the autopilot. The waypoints provide general steering points, but hand-flying the aircraft allows you to be more flexible.

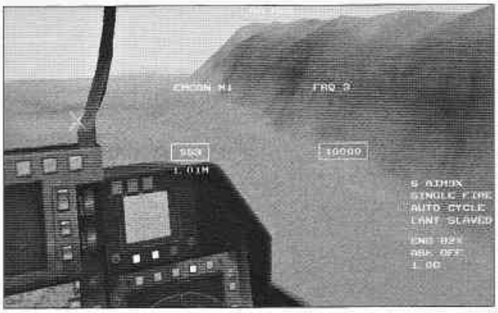


Figure 31

As you fly towards waypoint 2, you see that the top of the mesa rises above our current flight level of 10,000 feet (Figure 31). This should shield you from any search radar that the bogeys may be using as they approach. There is no need to 'hide in the sand' just yet, but you should start losing altitude slowly so as not to end up silhouetted against the sky once you clear the mesa, and also in case you need to drop into the ravine to the east. Navigate around the eastern end of the mesa, but

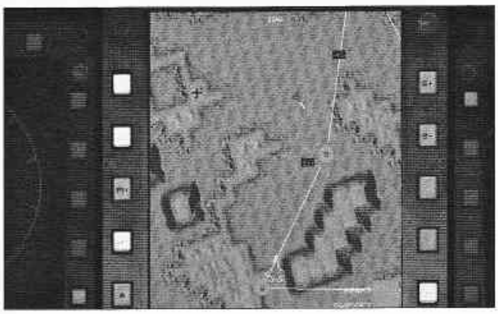


Figure 32

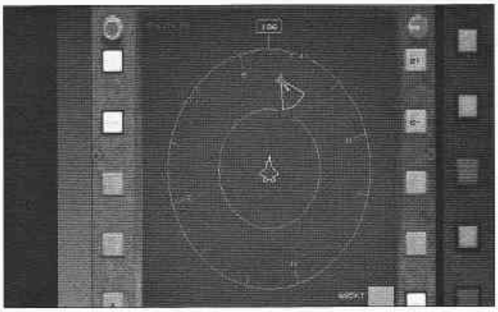


Figure 33

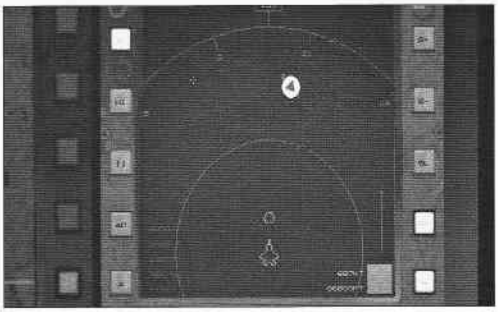


Figure 34

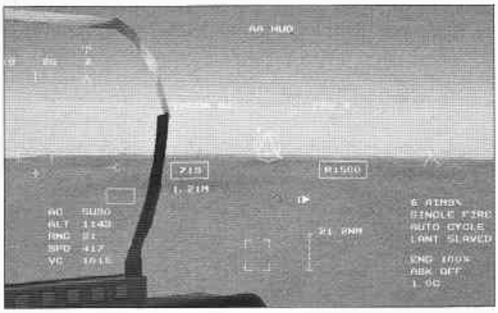


Figure 35

keep an eye out for the inbound aircraft – they are out there somewhere!

Shortly after turning the corner at waypoint 2, the bogeys appear on the TSD, heading right towards the anticipated intercept point at waypoint 3 (Figure 32).

Checking the Defence MFD (Figure 33), you see that you are well outside of the bogey's radar detection range. At a distance of approximately 30 miles, a visual sighting extremely unlikely – you are right where you want to be, undetected and in command of the intercept.

Press the T key to automatically add the bogeys to the shoot list. The IRST system allows you to target, track, and even launch IR guided missiles without alerting the bandits. The Attack MFD now displays target data in the lower left-hand corner, identifying them as Su-30 aircraft (Figure 34). Their altitude, range and speed are visible in the target data block. You still have a ways to go before they are in weapons range, so stay low and offset from their course to avoid detection.

Switching to the target padlock view, the targets are visible in the HMD at your 1 o'clock position. The target aspect is still slightly near the forward quarter, as indicated by the aspect line pointing to the 4 o'clock position (Figure 35). Accelerate, but stay on your current course, offset from that of the bandits in order to remain undetected. Once you are more directly abeam of the targets, turn in to prosecute the attack.

Notice that the target icons, as viewed in the HMD, are solid triangles. This verifies that they are entered into the shoot list. The target caret is still well above the top of the range bar – well out of range for the AIM-9X missile. The missile seeker head indicator is visible near the middle of the HMD. The sweeping motion of the seeker head is an indication that the missile has not yet locked on to the target. It also serves to remind us that the missile is in firing position. In this instance, the AIM-9X missile is being carried externally – its seeker head is always out in the air stream. However, if this were an internally carried missile, and it was still in the weapons bay, no seeker head indicator would be visible until the first trigger pull extends it out of the bay. Whenever you anticipate you will be firing an internally loaded sidewinder missile, look for the seeker head

lest you pull the trigger and nothing happens! Likewise, when firing radar guided missiles, be sure to check that you are at EMCON Level 3 or above.

It is time to turn towards the bandits and tighten the pursuit. Ideally, you want to end up right behind them before they reach the mesa. Push the throttle a bit to increase your closure rate. As you do so, take a look at the IRST image in the Up Front Panel display in order to obtain a clear visual identification of the target aircraft (Figure 36).

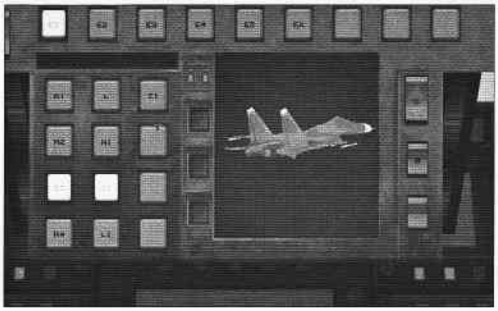


Figure 36

Close the gap and move in behind the bandits. They are now just inside firing range – about 7 miles out – and are still unaware of your presence. You are lined up perfectly. The target aspect indicator is pointing straight up. Notice that the 'Shoot' cue has appeared in the HUD, as well as the 'Missile Steering Cue' and the 'PK Indicator Circle' (Figure 37). The avionics has determined that you 'can' take a shot, but at this range, it is doubtful you will score two kills. You have a high closure rate, and every second you can wait increases your odds dramatically. As long as the targets remain cooperative, move in closer and wait until the PK circle has expanded to its maximum extent before announcing yourself with a pair of AIM-9X missiles.

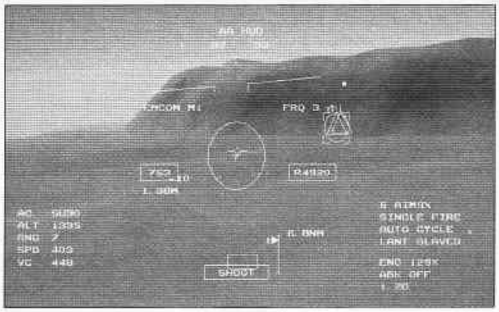


Figure 37

The bandits have reached the mesa and appear to be circling to sweep the area behind them before climbing over it. Your chances of remaining undetected are getting slimmer by the second. On the positive side, the PK indicator is nearly maximized, and the range caret is in the heart of your weapon's effective range (Figure 38). There is no better time. Take the shot now before they realize you have them in your sights and take a shot of their own. If you are lucky, both missiles will strike their targets. Even if only one scores a hit, you will have improved the odds and will be in excellent position to take advantage of the confusion sure to ensue as they attempt to evade. Time to ruin someone's day. Pull slightly to centre the missile steering cue, then shoot – FOX-2!

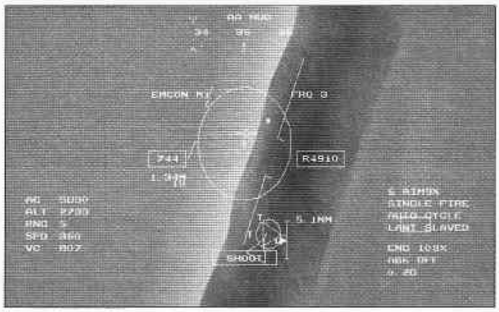


Figure 38

As expected, the Su-30 pilots were taken completely by surprise. One plane fell to the missile shot. The other managed to evade, but you are in excellent position to saddle up and finish the job with guns(Figures 39 and 40).

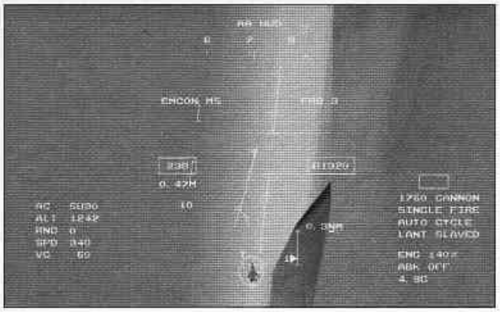


Figure 39

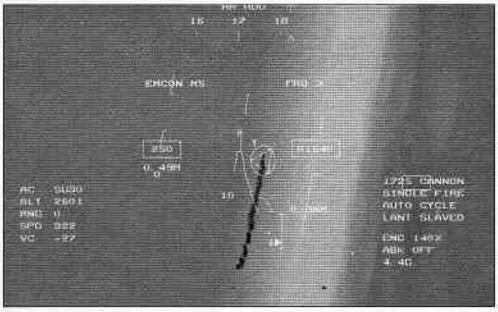
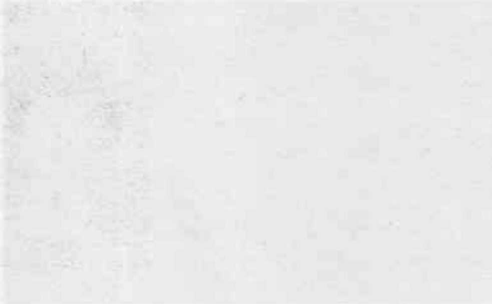


Figure 40

Once the bandits are dispatched, your mission will end. If you like, select 'CANCEL' and you will have the opportunity to continue to your landing waypoint. Who knows the AWACS crew may find some other business for you to attend to as well!



Chapter 3

Learning to Fly

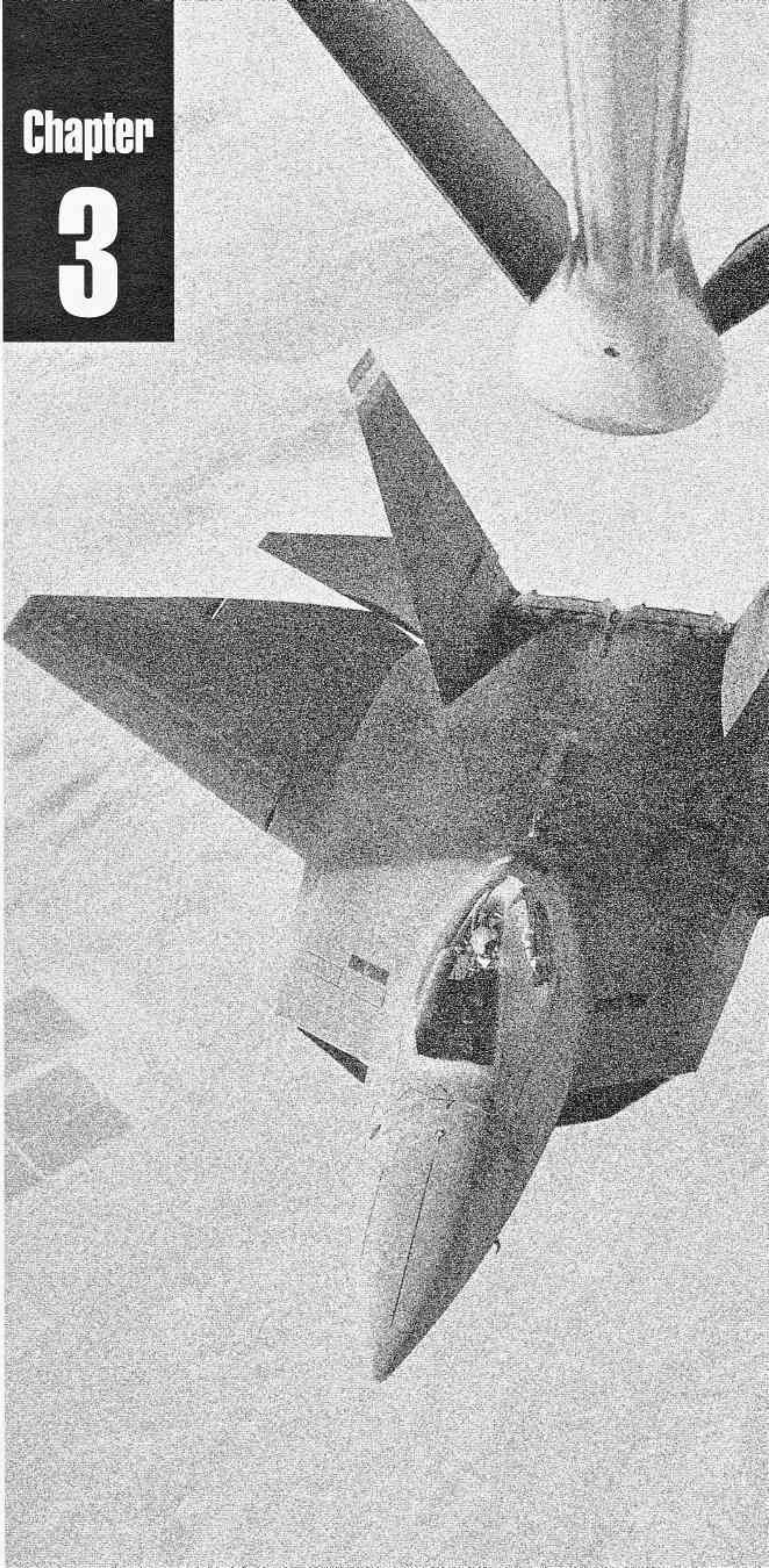
Preflight Checklist

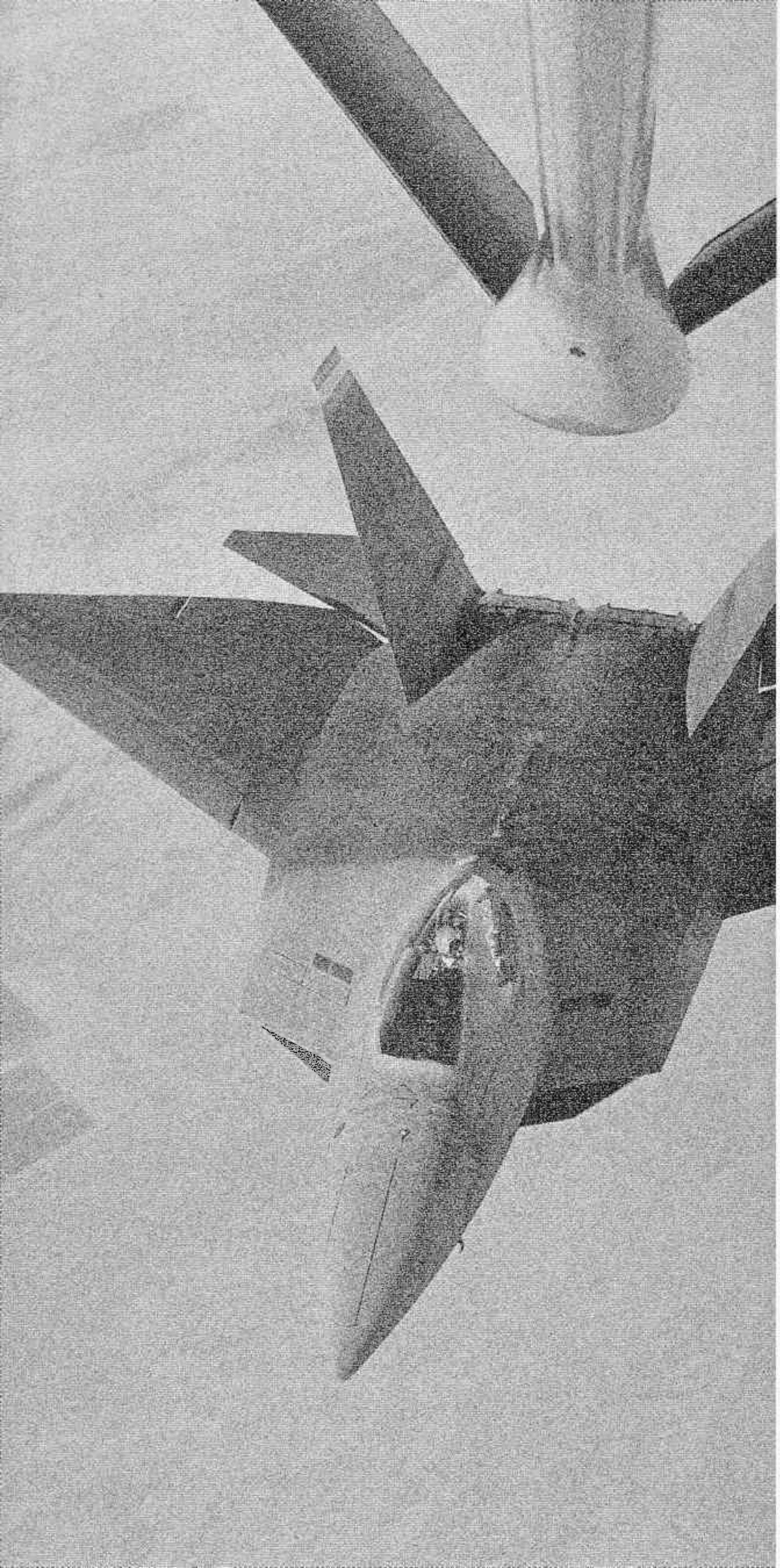
Basic Flight Principles

Airborne Refueling

Landing

Damage and Emergencies





CHAPTER 3

Chapter 3 Learning to Fly

Today's most advanced fighter aircraft are the products of cutting edge aerodynamic design technologies. However, in order to achieve the extraordinary performance qualities enabled by these designs, most modern fighter aircraft are inherently unstable in flight. Without the intervention of flight computers between the pilot and the plane, these 'fly-by-wire' aircraft simply tumble out of the sky. The F-22 ADF represents the state of the art in this aircraft design philosophy; an aircraft featuring outstanding manoeuvrability, super-cruise capabilities and low radar observability.

One might argue that modern combat aircraft are flown by computer more than they are by hand. However, fly-by-wire can only make the aircraft stable, it is the pilot who makes the aircraft deadly. This chapter will walk you through the basic procedures and systems you will need to master in order to do just that - make the aircraft an effective tool of air combat. Once you have the basics under your belt, you will be able to take advantage of the information in Chapter 4, 'Performance', in order to wring the absolute most out the F-22.

Part I Preflight Checklist

Achieving mission success requires that you first formulate a plan before charging off to engage the enemy. Planning begins long before you climb into the cockpit, but does not stop there. Throughout your mission, you will constantly be reevaluating your plan and adjusting to the situation at hand. F-22 ADF/TAW is more than simply a game of tactics; it is one of strategy as well. Many of the missions you fly will start out in the air, but many will begin on the ground as well. The first few sections of this chapter will concentrate on the latter situation, but the items on the 'checklist' apply equally to the former. If a mission starts you out while airborne, do not hesitate to use the 'pause' function to give yourself time to become situated. After all, you would not have gotten to this point without some degree of planning.

The first thing you need to do after your crew chief has strapped you into the cockpit is to make sure everything is in order. Start with your controls. If you are using a programmable joystick and throttle, you may need to send them a 'wake up call' to make sure that they will operate properly. Since controls tend to drift from one session to the next, pressing ALT-C to centre them properly is highly recommended. 'Lighting the fires' only to careen wildly out of control is not only embarrassing, you might end up destroying your own aircraft or those of your wingmen. Remember, unlike many other simulations, you CAN collide with other aircraft while taxiing around the airbase in F-22 ADF/TAW.

Make sure that your radio is set to the airbase frequency by pressing the 1 key on the top row of the keyboard and that radio transmissions are enabled (EMCON Level greater than 1, TAW only). The tower should contact you shortly for a radio check by requesting that you 'Go to Noise Con 5'. Acknowledge this request by pressing the Y key (this has been removed in the TAW patch). Taxiing instructions should be provided shortly. If you are unsure of what your scheduled take off time is, ask the tower to 'Say my takeoff time' by pressing the 1 key three times in succession. Make sure your wheel brakes are set by pressing the C key, however, wait until you get clearance to taxi before starting your engines in order to conserve fuel.

While you are waiting for clearance to the active runway, take the opportunity to adjust the settings on your multi-function displays (MFDs). The choice of what to display boils down to a matter of personal preferences. However, common sense dictates that you should set up your displays to provide yourself with the information you need in order to avoid threats along your mission route. The following are suggestions for a reasonable 'default' setup.

Press the **ALT-G** keys to bring up the mini-MFD views in the HUD and HMD. This will enable you to maintain a high level of situational awareness without the need to leave an 'out of cockpit' view to check the displays. A copy of the Defence MFD will appear in the lower left-hand corner of the screen, and a copy of the TSD will appear in the lower right. The currently displayed range of the MFDs is shown numerically just above and to the right of each mini-MFD.

Switch to your Tactical Systems Display (TSD). If you wish to edit your first few waypoints, now is the time to do so while you are not distracted by the task of flying the aircraft. If you like maps, turn on the map display. While this does clutter the display somewhat, the colour-coded target icons maintain reasonable visibility. The map provides information on the surrounding topography and this can be very handy if you are trying to use terrain masking to achieve a stealthy flight profile. Under most circumstances however, the clarity of the TSD without the map display is preferable. If you do choose to display the map, turning off the 'place names' display is recommended. These generate a great deal of clutter with little or no value to your mission success.

You can toggle the display of air and/or ground targets off to reduce clutter on the TSD. Note however that disabling target displays on the TSD disables them on the Defence and Attack MFDs as well. Prudence suggests that you leave these enabled in order that you may identify and respond to threats that may appear along your route.

You may wish to adjust the range displayed on the MFDs to allow you to see other aircraft and targets near your F-22 more easily. At the maximum range setting, it is difficult to differentiate objects near your aircraft, especially in the mini-MFDs. Conversely, short ranges are best employed as you engage targets, but may leave you blind to approaching threats. The intermediate, 100-mile range setting offers a good compromise between object visibility and early warning. Note that if Auto EMCON is engaged, the avionic may overide your manual settings. If you wish to prevent this from happening you must take manual control of the EMCON system.

A small version of the artificial horizon display, along with altitude and airspeed information is repeated in the lower right-hand corner of

all four of the main MFDs. Turn off the artificial horizon display if you find it distracting. The altitude and airspeed text will remain visible at all times.

Switch to the Artificial Horizon MFD and activate the autopilot display. This will provide you with quick access to autopilot functions without the need to switch your main displays out of their normal modes. The pitch ladder, heading, altitude and airspeed information normally displayed here is visible in the HUD (Heads Up Display). Unless the HUD is damaged, there is little need to go 'heads down' to get this information.

As a final item on the takeoff checklist, you may wish to review what your EMCON settings should be for the mission. Auto EMCON does a fair job of balancing information gathering and sensor emissions with the need to maintain stealth. However, if you wish to maximise your ability to penetrate enemy territory undetected, you should consider setting EMCON Levels manually. At EMCON Level 1, nearly all electronic emissions are shut down providing you with the best chance of reaching your target with the element of surprise intact. Do take note of the fact that although radio transmissions were (incorrectly) allowed in F-22 ADF at EMCON Level 1 this is not the case in F-22 TAW. If you wish to send a radio message, you will need to engage EMCON Level 2 or higher.

As a rule consider using Manual EMCON Level 1 for all missions until such time as you need to send radio messages, deploy radar guided munitions or you are involved in combat. At such times, increase your EMCON Levels as needed but remember to reduce them as soon as the situation permits. There is little, if any downside to maintaining emissions silence as long as possible and a great deal of potential risk if you expose yourself to detection needlessly.

Taxiing

Once you receive clearance to taxi to the active runway, start your engines by pressing the square bracket keys [and]. Close the canopy by pressing the [key. If you forget to do so, it will close automatically once you start moving. Release the wheel brakes, and then gradually advance the throttle to between 65 and 70 percent in order to start moving. Once you have some momentum, bring the throttle back to idle. The F-22's engines are capable of very high thrust output; if you forget to back off on the throttle you will soon find yourself moving very rapidly! You may find it helpful to use only one engine while taxiing around the field. Since your available thrust will be only half of the normal amount, a larger amount of throttle movement is necessary. The advantage however, is that you can maintain finer control over your acceleration. Just remember to have both engines running before you try to take off.

Your F-22 is extremely stable while taxiing. Flipping over while taxiing is not a problem. However, the faster you are moving, the wider your turns will be. Therefore, try to keep your taxi speed around 20 knots in order that you may be able to negotiate turns in the taxiway. Short taps on the wheel brakes may be necessary to control your speed, especially as you approach turns. Control the nose wheel steering by using your rudder pedals if you have them, or the rudder keys (the and keys) if you do not. In addition to the nose wheel steering system, the toe brakes (the < and > keys) can be employed to help you negotiate tight turns.

Once you have clearence to taxi the waypoint caret on the HUD compass tape will provide you with cues to direct you to the proper runway for takeoff. Turn in the direction of the waypoint caret as you start moving. As you approach intersections, the caret will indicate whether and in which direction you should turn. The tower may have instructed you to 'hold short' of the active runway. If so, cut the throttle, apply the wheel brakes and come to a complete halt on the taxiway as you near the intersection with the active runway. Avoid sticking your nose out onto the active runway as other aircraft may be landing ahead of you. At the least, you may cause another aircraft to abort its approach. At worst, you may cause a collision that will bring your mission to a swift and ignoble end.

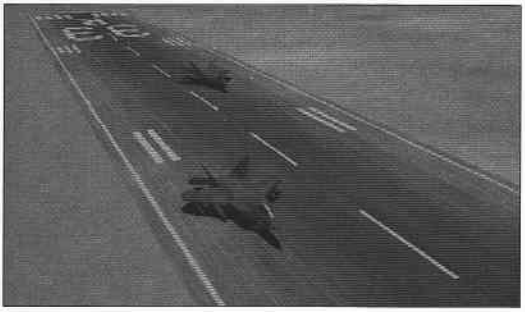


Figure 1

When the runway is clear, the tower will instruct you to 'line up'. Release the wheel brakes, advance the throttle and proceed onto the runway. Align yourself between the centre line and the right edge of the runway, then move up far enough to allow your wingmen to turn in and line up behind you - a few hundred feet should be enough. Be sure you are pointed straight down the runway to avoid drifting once you begin your takeoff roll. When you are in lined up and in position, as shown in figure 1, cut the throttle and apply the wheel brakes while you wait for the tower to give you final clearance to takeoff.

Taking Off

When the tower gives you final clearance, take note of any instructions regarding departure heading and altitudes. Once you are ready for takeoff, release the wheel brakes and advance the throttle smoothly up to 100 percent power. The F-22 has an excellent thrust-to-weight ratio, so there is no need to use afterburner for takeoff in most cases - it just uses up your valuable fuel resources. An exception to this might be if you are taking off 'short' or scrambling to react to incoming threats. If necessary, use the rudder to fine-tune your alignment

during your takeoff roll. Be very careful to apply only small adjustments. Large rudder movements may result in instability and cause you to drift off the runway - or even worse, into one of your wingmen! As your airspeed increases past 160 knots, gently pull back on the stick until your nose wheel lifts off the runway. The main gear will follow shortly. If you are heavily laden with extra fuel and ordnance, your takeoff speed may need to be slightly higher.

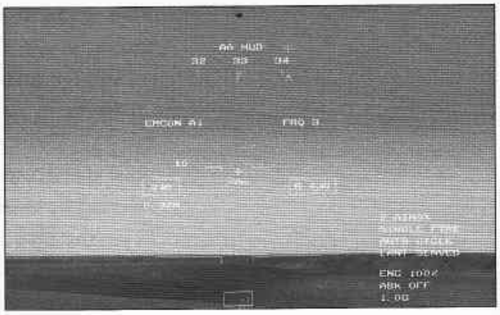


Figure 2

As you become airborne, maintain a gentle climb of about 5 to 10 degrees to avoid bleeding airspeed unnecessarily (Figure 2). Remember to raise your landing gear once you are clear of the runway. Although the avionics will automatically retract the gear if you exceed 285 knots, there is no sense in creating extra drag during your climb out. As your speed increases, you can increase your rate of climb. Follow the departure controller's instructions in order to avoid other air traffic in the area.

Once you have achieved your departure altitude, turn onto your waypoint heading and proceed with your mission objectives. Your speed should have increased sufficiently for you to climb to a higher, more fuel-efficient altitude for the first part of your route. Switch your radio to frequency 2 by pressing the **2** key on the top row of the keyboard. This will allow you to monitor Airborne Warning and Control (AWACS) directives as well as the radio chatter from other flights in the area. If your mission plan calls for Combat Air Patrol (CAP) duties, notify the AWACS controller that your flight is available.

Scramble Takeoffs

If you need to takeoff in a hurry, whether because the base is under attack or there are enemy aircraft inbound nearby, get to the runway as soon as possible. Which runway is not critical, but make sure that when you do reach it, you turn towards the end that is farthest away. Line up as quickly as you can and apply maximum throttle in order to make your takeoff roll as short as possible. If time is absolutely of the essence, find a long piece of taxiway, apply maximum throttle and immediately pull back on the stick. As your airspeed increases the nose will come up. Be careful not to veer off the taxi way on to the grass or sand. Taking off on a taxiway extends your takeoff roll slightly, but trying to get airborne across rough or unpaved terrain is nearly impossible. Watch out for other aircraft that may be taxiing to, taking off or landing on the active runways. A Collision will end your mission as surely as the enemy will. Employing these procedures is reckless at best, but since the game does not penalise you for them

(unlike a real-world airbase commander would), use them if you must, but do so with caution. Once the main landing gear have left the tarmac, promptly retract them and reduce back pressure slightly to allow the aircraft to accelerate.

Taking Off the Easy Way

The F-22's autopilot is fully capable of manoeuvring your aircraft to the active runway, delivering you to the final line up point and taking off. Select the take off autopilot mode, and engage the system once you have acknowledged your taxiing clearance. Once your aircraft is airborne, the autopilot will automatically switch to waypoint mode.

While this may be regarded as 'cheating' in some circles, it does get you there in short order and allows you to concentrate on other set up items in the interim. If you need to 'scramble', this is definitely a method to consider.

If you do not want to be bothered with taxiing to the runway, use the 'Time Skip' feature. Pressing SHIFT-S will advance you to the next scheduled action in the game. In most cases, a couple skips will have you sitting on the end of the runway, ready for final clearance. Be careful not to skip too far however, as the NEXT scheduled action may find you airborne in the midst of a bevy of trigger happy enemy pilots.

Part II Basic Flight Principles

In this section, we will examine the basic aspects of flight. Chapter 4, 'Performance', provides a detailed and much more advanced discussion on how to maximise your F-22's manoeuvrability.

Manoeuvring with Lift

Four forces act on your aircraft while in flight: lift, weight, thrust and drag. When all of these forces are balanced, the aircraft will fly smoothly in a straight line. In order to manoeuvre your aircraft, you will need to alter the balance of these forces. The most effective way to do this is by manipulating the lifting force, using it to 'pull' the direction of flight one way or another.

Lift is generated by the movement of air over the wings and pushes upwards, perpendicular to the wings. The 'lift vector' is a mathematical representation of this lifting force. To simplify the discussion for the moment, visualise your aircraft in level flight. You can imagine the lift vector as an arrow pointing vertically, straight up out of the cockpit. By moving the controls, you change the orientation of the aircraft, and consequently the orientation of the lift vector, relative to the world around you. When you move the stick sideways, the aircraft rolls in the direction of movement, pointing the lift vector to one side or the other. Moving the stick forwards or back pitches the aircraft, as well as the lift vector.

So, to turn the aircraft, just aim the lift vector, right? Well, only half right. Simply rolling the aircraft will not make it turn. You can prove this for yourself by pushing the stick to one side and watching what happens. You roll, but you do not turn. In order to turn, you not only have to aim the lift vector, you must increase it as well, unbalancing the forces so that lift 'pushes' the flight path in a different direction. One way to accomplish this is by increasing the angle of attack (AoA).

Angle Of Attack

Angle of Attack is the degree to which your wings are tilted relative to the direction of the airflow. For example, when your aircraft is flying straight, the AoA is nearly zero. By pulling back on the stick, you raise

the nose relative to the direction of flight, increasing the AoA. Generally speaking, as AoA increases, the amount of lift generated by the wings also increases. A positive AoA results when the leading edge of the wing is higher than the trailing edge with respect to the airflow. If you push forward on the stick, the leading edge of the wing is lower, and the AoA is negative.

Comparing the position of the flight path marker on the HUD with the centerline indicator gives you an indication of AoA. The farther apart these two markers are, the greater the AoA. You can envision the AoA as the difference between where the aircraft is going – the flight path marker – and where the aircraft is pointing – the centerline indicator. If the flight path maker is below the centerline indicator, the aircraft is tilted up and experiencing a positive AoA. If the flight path marker is above the centerline indicator, the inverse is true and AoA is negative.

However, increasing AoA not only creates more lift; it induces more drag as well. As a result, you will lose airspeed as you increase pitch unless you also increase thrust. If your AoA is too high, the wings will no longer generate lift and the aircraft will stall.

There are times when a high AoA and a lot of drag are desirable, such as during landings. Other times, during a dogfight for example, bleeding too much speed will leave you incapable of manoeuvring against your opponent allowing him to bring his weapons to bear.

Turning the Aircraft

To make a smooth, controlled turn, you will need to coordinate stick movement in both pitch and roll. Use the pitch ladder and the flight path marker, both of which appear in the HUD, as a guide. You will want to maintain a moderate amount of bank with just enough pitch added so that the flight path marker remains even with the horizon. Figure 3 illustrates this with the aircraft in a 45-degree bank. You may also need to add a little thrust to compensate for the loss of speed due to drag.

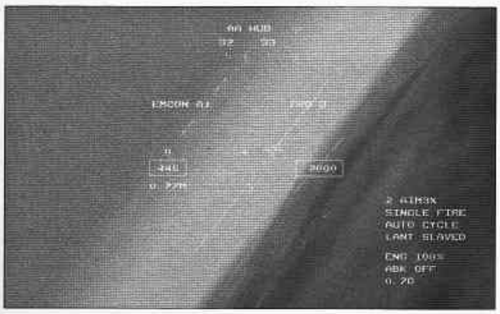


Figure 3

Executed in this manner, you will turn smoothly and gradually, without losing altitude. This type of turn is often used while setting up a landing approach or flying in formation.

Rudder Turns

At moderate to low speeds, it is possible to turn the aircraft using just the rudders. Rather than banking and pulling back on the stick, the rudders can be used to yaw the aircraft and skid around a flat turn. An

example of a rudder turn is shown in Figure 4. Full left rudder has been applied here, swinging the nose of the aircraft to the left. Notice how the velocity vector is offset to the right of the centerline indicator. If pressure is maintained on the rudder, the nose of the aircraft will lead the velocity vector around a turn to the left.

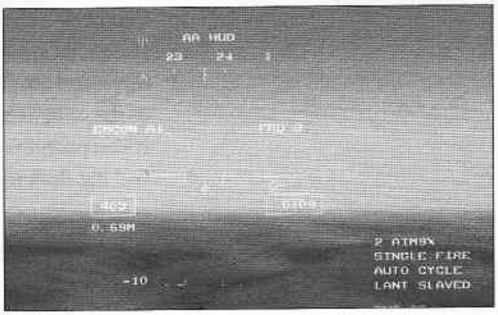


Figure 4

Turning with the rudders is extremely slow and of little usefulness under most flight conditions. However, this technique is very effective while landing, refueling, or strafing with guns or rockets.

During a landing, you can use the rudders to fine-tune your alignment with the runway while maintaining your wings level to the ground. For small changes in direction, this is preferable to a banked turn; you are less likely to overshoot. Similarly, when you are lining up with the refueling boom, rudder turns allow you to adjust course without changing altitude. Finally, when attacking with guns or rockets, use the rudder to walk your aiming point from side to side in order to attack targets displaced slightly from your current flight path.

As noted earlier, the nose of the aircraft leads the velocity vector during a rudder turn. Consequently, the aircraft's nose will tend to bounce back towards the velocity vector if rudder pressure is released all at once. You can avoid this effect by releasing rudder pressure gradually. Remember that the aircraft is flying towards where the velocity vector is pointed rather than where the nose is pointed. Time your release so that you allow the velocity vector to settle on the desired heading.

High-G Turns

Banked turns are fine under most flight conditions. However, such slow and predictable turns are not what you want while engaged in a dogfight. You want to turn as quickly as possible. In order to turn sharply you need to maximise the effect of lift pushing you in the direction you wish to turn. Roll the aircraft nearly vertical, about 90 degrees of bank, as shown in Figure 5, then pull back on the stick - Hard! This dramatically increases the lifting force and pushes the plane strongly in the direction of the lift vector.

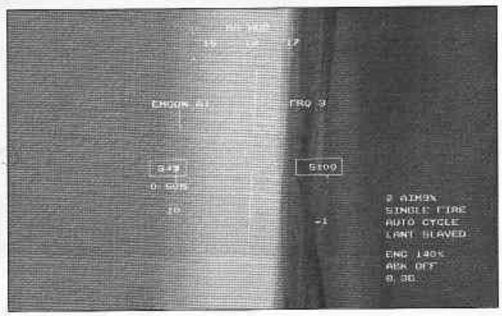


Figure 5

Since the pilot is strapped into the aircraft, he feels the effects of this force as a dramatic increase in the G loading - the force pressing him into the seat. Pull too many G and the pilot will black out as the blood is forced away from his head.

A consequence of executing a high-g turn is that by tilting the lift vector away from the vertical, your aircraft will start to lose altitude. If your angle of bank is precisely 90 degrees, none of your lift is being used to hold the aircraft up - it is all being used to turn. In order to avoid losing altitude, you will need to decrease the bank angle slightly in order that some of your lift can continue to act against gravity.

You will also notice that you start to lose speed because of the increased drag that is incurred during this type of manoeuvre. As you slow down, you will need to reduce the bank angle even further in order to maintain altitude. This is because as your airspeed decreases, so too does the total amount of lift your aircraft is able to generate.

Once again, this is a broad simplification as many more variables, such as altitude, airspeed, thrust, drag, effect how your aircraft manoeuvres. Chapter 4, 'Performance', provides an in-depth look at these factors and will arm you with the information you need in order to realise maximal turn performance.

Thrust Vectoring

Thrust vectoring is the ability to alter the direction in which the engine is providing thrust. Shifting the exhaust away from the centerline provides an additional force component that can be applied to manoeuvres. Thrust vectoring has been around for many years, used predominantly in rocket technologies where, in some cases, it may be the only way to provide steering capability. Its application to aviation is a much more recent innovation and is only seen in the most advanced designs. The F-22 is equipped with thrust vectoring capabilities that allow the engine's exhaust to be deflected either up or down relative to the centerline of the aircraft. To enable thrust vectoring in F-22 ADF, press and hold the 'tilde', or '~' key while moving the control stick forwards or backwards. The direction of the F-22's thrust vectoring is linked to the action of the control surfaces. The effect is to increase pitch authority beyond that provided by the control surfaces alone. Thrust vectoring makes your F-22 ADF an extremely agile and capable fighter, despite its relatively large size.

The effects of thrust vectoring are most pronounced at speeds below 350 knots. As airspeed climbs above 400 knots, the effect becomes less and less noticeable. Depending on airspeed and the amount of control stick deflection applied when is engaged, thrust vectoring allows you to pitch the nose considerably relative to the direction of flight; you can gain as much as 15 degrees, or more, almost instantaneously. Unfortunately, those additional degrees come at a cost. Because thrust vectoring significantly increases your aircraft's AoA, airspeed bleeds off at a prodigious rate, especially as it falls below 300 knots.

In order to avoid excessive loss of airspeed, avoid prolonged applications of thrust vectoring. Short bursts are far more effective.

For example, if you are in a turning fight but cannot seem to get your nose in front of the bandit for a shot with your guns? A light tap of thrust vectoring can blip your nose forward just enough to squeeze off the shot. If you get overzealous however, you will soon find yourself 'out of airspeed and out of ideas' - a bad place to be in a combat situation.

Recovering From High AoA Manoeuvres

When you are in a hard turn, the centerline indicates where your nose is pointed, but the flight path marker indicates where your aircraft is heading. Remember that in a high AoA condition, the nose of your aircraft is leading the direction of flight by a fair margin. When you release the controls abruptly, the nose of your aircraft will have a tendency to 'snap back' towards the flight path marker as the forces acting upon it equalise. This condition is particularly acute when thrust vectoring is used, both because of the greatly increased AoA as well as the sudden change in the direction of thrust. To minimise this problem, bring the controls back to centre gradually. If you are using thrust vectoring, avoid disengaging it until you have centred the controls. When you are aiming to roll out of your turn on a particular heading, bear in mind that it is the flight path marker that will determine where you end up, not the direction your nose is pointing.

This can be particularly problematic when you are trying to bring your guns to bear on a bandit while executing hard manoeuvres. The sudden movement of the nose will make accurate gunnery almost impossible. In these situations, smooth and gradual movements will allow you to line up your shot with much greater accuracy. If you employ thrust vectoring to gain angles on your target, either take the shot before you disengage it, or pull well enough beyond your target to allow for the sudden shift backwards that your nose will make when you do disengage it. Allow the nose to stabilise before pulling the trigger and you will waste much less ammunition.

Stalls and Low Speed Flight

The F-22 is extremely resistant to stalling. Large wings and control surfaces, coupled with advanced flight control computers, give you the ability to remain airborne, even at extremely low airspeeds and high AoA. Stalling, as modeled in F-22 ADF/TAW, is not so much the loss of control as it is merely the loss of airspeed. Recovery is simply a matter of allowing the airspeed to climb back up until you have adequate control over the aircraft. If you have enough altitude to do so, allow the nose to fall below the horizon and use gravity to assist the

engines in getting back up to speed. If you are at low altitude, level the wings, push the throttle to the limits, and avoid pulling back on the stick until you regain some speed.

With its resistance to stalls and extraordinary stability at high AoA, it is actually possible to put the F-22 ADF/TAW flight model into a tail slide! Although this manoeuvre has absolutely no combat value, it does make for an interesting 'air show' display.

To accomplish this trick, start out by flying straight and level at a relatively slow airspeed. Pull back hard on the stick until your nose is pointed straight up. Centre the controls and cut the throttle to minimum, applying the airbrake to slow yourself down as quickly as possible. As airspeed drops, you will need to use small movements of the stick and rudders to hold the nose in the vertical. Your airspeed will eventually drop to zero, leaving the aircraft suspended in mid-air on its tail. Continue to make adjustments with the controls to combat the tendency of the nose to fall. This is somewhat like balancing a broom handle on your fingertip - small movements can have large effects. Watch your airspeed. You will soon see that it is negative! You are now falling towards the ground, tail first! To recover from this manoeuvre, simply push the stick forward and gradually apply full throttle as your nose falls back to level. Try making an Air Combat Manoeuvring Instrumentation (ACMI) recording of this trick if you want to watch from the sidelines.

Low speed flight presents few complications for the F-22 since the flight computers will lend a hand in keeping the aircraft stable. We have already noted however, that as the aircraft slows, the capability of the wings to generate lift is reduced. This will necessitate increasing pitch to compensate for the loss of lift and herein lies the rub. At low speeds, 140 to 180 knots, the aircraft will actually be sinking although the view out the cockpit indicates that you are nose high. While this is exactly the condition that you want to be in if you are landing, it is not one in which you wish to find yourself if there is no runway ahead! Although it is possible to survive a belly landing, you will not be able to take off again and your mission will be effectively over. At very low speeds, altitude loss becomes even more severe and the high AoA only makes matters worse.

The F-22 has ample thrust to lift you out of reach of the sand crabs, but there is a delay incurred before the effect is felt on the flight path. In other words, the situation will get worse before it gets better. Remember to pay close attention to the flight path marker. This is an indicator of where the plane is headed. Do not allow yourself to be lulled into complacency simply because it 'looks' like you are pointed skywards.

Low Level Flight

Flying nap-of-the-earth is an excellent way to avoid detection as you make your run in to a bombing target. This technique makes you less visible to enemy radar for two reasons. First, because you make the most of terrain masking - dipping into valleys and hiding behind hills. Second, even if you cannot hide, you are forcing the enemy radar to pick you out of the ground clutter.

Of course, buzzing along at tree top level is an unforgiving activity that calls for a steady hand on the stick. You will not have the cushion of several thousand feet of altitude below you to compensate for errors. You do not want to have to pull up hard or you will nullify the benefits of flying so low in the first place.

The easiest way to fly nap of the earth is to use the autopilot, dialing in an altitude setting of 200 feet (although you can set it lower, the autopilot will treat such settings as being equivalent to 200 feet). While the autopilot does a capable job of keeping the aircraft low, there a few considerations that you should bear in mind.

First, if you are in waypoint mode, the autopilot will follow the preprogrammed route slavishly, even if a slight deviation would result in a lower flight path. For example, if the waypoint route happens to run directly over a tall mountain, the autopilot will fly your F-22 right over the peak. Although you will stay 200 feet off the 'ground', the ground may be the highest point for miles around. Alternatively, if your route happens to parallel a canyon, the autopilot will follow the programmed route rather than steer you into the canyon, which may afford better cover. Finally, you will need to edit each waypoint's altitude before you reach each it. Otherwise, you may find yourself suddenly climbing up to cruising altitude. As a result, heading mode is a much better choice for autopilot terrain following than waypoint mode. Heading mode allows you to easily modify your route in order to avoid, or take advantage of, the local terrain.

A second potential problem with autopilot terrain following involves the way in which the autopilot handles large negative changes in altitude. Autopilot systems have generally taken one of two approaches when reacting to a sudden drop in terrain. Either they pushed forward on the stick hard, momentarily generating high negative g, or they 'ballooned' over the intervening terrain, resulting in a temporary, but dramatic gain in altitude relative to the terrain. The F-22 ADF's autopilot takes a third, completely different approach to this problem. Rather than pushing the nose down, the F-22 ADF's autopilot will roll inverted, then pull back on the stick, much as a human pilot would do in order to lose altitude in a hurry.

While this eliminates the negative G problem, and alleviates ballooning over intervening terrain, rolling the aircraft creates its own

set of problems. Visibility to enemy radar systems is increased dramatically during the moments when the aircraft has its wings oriented perpendicular to the ground. Granted, this is a brief moment of vulnerability, but it is a point worth considering if stealth is of the utmost concern.

Flying nap-of-the-earth manually carries only the disadvantage of crashing into the ground if you make a piloting error. This certainly ratchets up the excitement level, and nothing compares with the feeling of speed created while zigzagging through valleys and canyons. Flying a low level route manually is by far the best way to approach a target undetected as you have the most flexibility for taking advantage of the terrain along your route. In practice, the possibility of error is minimised to a very large degree if you adhere to the following guidelines.

The F-22's avionics constantly monitor the position and speed of the aircraft as well as the character of the surrounding terrain through the use of stored digital maps and satellite positioning technology. A 'terrain following box' is projected onto your HUD that provides you with the cues you need in order to follow a low-level route while maintaining a minimum of 200 feet of clearance above obstacles in your way. Simply keep your flight path marker centred in the box, as shown in Figure 6, and you will be ensured of clearance.

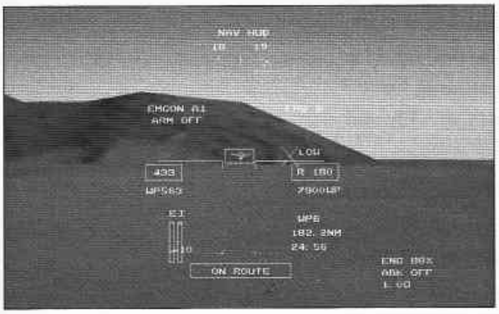


Figure 6

When you cross a sharp cliff or some other drop in the terrain, you can choose how to react. For example, if the terrain continues for a long distance at the lower altitude, rolling inverted and pulling down towards it before righting the aircraft is desirable. This maintains the 'tight to the terrain' flight path and avoids ballooning. If the drop is steep but covers only a short span of distance, pushing forward on the stick to dip into the terrain before pulling up again is the advisable course. It is in these instances when the autopilot is, perhaps, overly aggressive as compared to manual flight. For example, when you are crossing a canyon, the autopilot will roll the plane in order to pull down towards the lower terrain. However, it may not even complete the manoeuvre before it is rolling upright again to clear the obstruction on the other side.

The use of afterburners when flying low level is not recommended. Higher speeds will require you to pull up sooner in order to clear obstructions. Likewise, your turning radius will increase and make following tight canyons much more difficult if not impossible. Finally, fuel consumption is at its most prodigious when flying at low level. Keep an eye on how much fuel you need in order to reach your target and make it home or to a refueling tanker.

Choose whichever method you feel most comfortable with. Hand flying the aircraft at low level is a lot of fun, but requires total concentration. Using the autopilot carries minimal penalties yet allows you to go 'head's down' if you need to use the MFDs for targeting or to assess the situation. In practice, you will probably use a combination of both. Regardless of which method you choose, do not panic if you sometimes see the altimeter drop sharply or you hear the 'ground proximity' warning. As long as the flight path marker is kept in the terrain following box, you will clear obstructions, even if the reading momentarily displays values considerably less than 200 feet. Besides, if you NEVER hear Betty 'bitch' about ground proximity, you are probably flying too high.

Of course, the above statement assumes that you do not make any wild variations to your course. If, for example, you are flying along a sharp cliff line, turning towards it may make it impossible to pull up soon enough to avoid a collision. Always use sound judgment when flying nap-of-the-earth to avoid the need to execute a low-level abort.

Low Level Abort

If you find yourself in a situation where you need to do a low-level abort, you must assess the situation and execute the appropriate manoeuvres without delay in order to avoid a collision with the ground. The first thing you should take into account is your speed. If you are moving rapidly, applying the airbrakes and reducing throttle may reduce your turn radius sufficiently to enable you to pull up. Use short bursts of thrust vectoring to help bring the nose around, but do not overdo it. Thrust vectoring will bleed off speed very quickly and may leave you wallowing.

If your speed is too low, applying afterburner may increase your speed to the point where you can manoeuvre clear of the obstruction. Bear in mind that it may be necessary to relax your pull on the stick momentarily in order to reduce drag and allow the speed to increase more quickly. Do not use thrust vectoring in low speed situations, as this will only make things worse.

Finally, do not fixate on object ahead and your current flight path to the exclusion of other options. Often, you can manoeuvre around the object or at least turn away to the extent that it gives you more room in which to pull up.

These considerations apply equally if you find yourself pointed towards the ground during manoeuvres and the 'ground proximity' warning starts to blare. For example, consider that you are pulling through a loop and the ground is rushing up at you. If you have not yet passed the point where you are pointed straight down, rolling upright and pulling away in another direction is more likely to avoid a collision than is simply pulling the stick back harder and praying for a miracle.

As a rule, pulling back on the stick in a panic will rarely solve your problem. Act quickly, but assess your options and you will be more likely to survive. It is a good idea to practice terrain following and low level aborts in the simulator missions so that they become second nature to you before relying on your ability to act coolly in a combat situation.

Using the Afterburners

Afterburners work by dumping raw fuel into the engine exhausts. The explosive burning of that extra fuel creates additional thrust. This is what is meant by 'wet' versus 'dry' thrust. F-22 ADF provides no separate afterburner control. Advancing the throttle moves you up to, and through 100 percent military power, smoothly into afterburner - the maximum 140 percent power setting. As you can imagine, the increased thrust gives you quite a speed boost. However, you will have to pay at the pump. Your fuel consumption rate shoots up dramatically whenever you use afterburners, reducing your effective range.

The range available to your F-22 depends on a number of factors: speed, altitude and the type of ordnance you are carrying. To give you an idea as to the effects of using the afterburners, consider the following. At 30,000 feet with a full internal fuel tank and no ordnance, you have a range well in excess of 3,000 miles. Light up full afterburners, and your range drops to less than one-tenth of this amount. Even at 110 percent, your range is cut by more than half. While using afterburners will 'get you there' in a hurry, 'there' will be a great deal closer to 'here' by the time your tanks run dry than if you had maintained a power setting of 100 percent or less.

There are times when you absolutely must trade jet fuel for speed or thrust. Afterburner use during a dogfight is very common. High G manoeuvres create a lot of drag and incur significant speed penalties. You will need to use the afterburners periodically in order to keep your speed within the best performance range. If the fight is not going your way and you need to 'get out of Dodge', afterburners can also help make good your escape.

Most of the time however, using the afterburners is unnecessary and should be avoided in an effort to conserve fuel and extend your effective range. Unless you have 'fuel to burn' or your survival depends on it, keep your throttle setting at or below the 100 percent thrust setting.

The Effects of Ordnance

The F-22 is equipped with internal bays to carry ordnance. This has the dual benefit of avoiding added drag as well as maintaining a small radar profile. However, ordnance carried internally still carries a

weight penalty that will reduce your operational range. Occasionally, your mission profile demands that you carry additional ordnance or fuel tanks on external hardpoints. At these times, weight is only part of the price you pay. The external stores add drag, compromising speed as well as range. To put it simply, the effect that ordnance has on your aircraft is that the more you carry, the more thrust you will have to generate in order to perform any given manoeuvre. In the case of a fully loaded aircraft, the effects may be so extreme as to make some manoeuvres impossible. Finally, external stores increase your visibility to enemy radar, reducing your stealth characteristics.

Dogfighting with a fully loaded aircraft is not recommended and should be avoided if at all possible. The enemy is rarely so accommodating however. If a fight is unavoidable, you may need to lighten the aircraft by jettisoning some of your ordnance. Pressing the **SHIFT • J** key will bring up a menu of choices: drop external tanks, drop Air-to-Ground (A2G) stores, or drop all stores.

The first items you should consider jettisoning are any external fuel tanks you may be carrying. Unless you can use the fuel in the external tanks to outrun the enemy, jettisoning them is preferable to dodging missiles with them under your wings. You will need to watch your fuel usage carefully over the remainder of the mission, but this is a small price to pay for being able to continue your mission at all.

If your mission calls for the destruction of ground targets, drop your A2G stores only if you have no other options. If you drop all of your A2G stores, you will be unable to complete the mission successfully. Consequently, this should be a 'last ditch' manoeuvre performed solely to save the pilot and the plane. A better plan is to consider how many bombs you need to complete the mission and drop any extras. Of course, the best plan is to avoid placing yourself in this position in the first place. Consider modifying your waypoint route to avoid enemy aircraft if possible.

Air-to-Air (A2A) ordnance is best used to eliminate the enemy threat early on, before you are forced into taking more drastic measures. Rather than dumping A2A weapons, shoot down the bandits with them. In any case, whether carried internally or externally, A2A weapons do not impose anywhere near the weight or drag penalties as their A2G brethren. Dumping them is almost never justified.

Maximising Fuel Efficiency

The F-22 is an amazingly sleek, low drag aircraft. Unlike the majority of combat aircraft, your F-22 is designed to allow sustained supersonic flight without using the afterburner - 'Super-cruise' capability. However, if you want to maximise your range, be prepared for a leisurely trip. Fuel efficiency is maximised at high altitude and low power settings. At 40,000 feet, your range is more than double what it

would be if you were flying at 10,000 feet. At 65 to 70 percent thrust, you can fly nearly three times farther than you can at 100 percent.

The speed you attain at these settings varies with altitude, total weight, and the presence (or absence) of external ordnance. As the saying goes, 'your mileage may vary.' Check the range value on the Systems MFD and make adjustments to the throttle as necessary to achieve the greatest possible range. For best fuel efficiency, use the Heading Autopilot in order to maintain steady flight.

Part III Airborne Refueling

Tucking yourself in beneath the tail of a KC-135 refueling tanker is one of the most challenging airborne tasks you will be called upon to perform in F-22 ADF/TAW. In order to refuel, you will have to precisely position yourself less than 100 feet below and slightly behind the tanker, in order for the tanker's trailing 'refueling boom' to be inserted into the aircraft.

A crewmember aboard the tanker, lying prone in a small compartment located in the tail, observes your approach through a rear-facing window. Using light and/or radio signals, the boom operator will direct you into position. Once there, the boom operator extends the refueling probe out of the boom and 'flies' it, by remotely manipulating a pair of wings on the boom, into a fueling receptacle located behind the F-22's canopy. Thankfully (for most of us), you will not have to maintain position manually once connected. Station keeping is automated in F-22 ADF/TAW.

Proper positioning during your approach is the key to success. Unlike probe and basket refueling, boom refueling requires you to deliver the aircraft to a specific point in space. Without a specific target to aim for, you will have to rely on other visual cues in order to achieve a refueling hook up. Refueling is far from easy. It is something that is perfected only through practice.

Locating the Refueler

Depending on your mission profile, a refueling aircraft may be located along either the outbound or return legs of your programmed waypoint route. Because external fuel tanks spoil the stealthy characteristics of the F-22, inflight refueling is common on long missions. Study your preflight briefing to determine where your scheduled rendezvous point with the tanker is located.

As you approach the refueling waypoint, contact the AWACS aircraft by selecting radio frequency 2 or 3 and request a vector to the tanker. In addition to the verbal instructions from the AWACS aircraft, the HUD will automatically switch to refueling mode and the waypoint caret will aid in directing you to an intercept. The refueling tanker

appears in the HUD as a targeted, friendly aircraft - a square icon surrounded by a circle. The range to the tanker, along with its current speed and altitude, are displayed in the target data block located in the lower left-hand corner of the HUD. If no tanker is available, the AWACS will instead direct you to the nearest divert airbase where you can land and refuel.

Obtaining Clearance to Refuel

Once you are within 15 miles of the tanker, select radio frequency 4 and request permission to refuel. The tanker will ask you to confirm 'weapons and nose cold.' Although your weapons are automatically 'safed' while in refueling mode, you will need to shut down your radar manually. Press the 'Y' key to acknowledge, and you will be cleared into 'pre-contact' position if no other aircraft is currently hooked up to the refueling boom.

Note the altitude at which the tanker is flying by checking the HUD target data block. This will typically be somewhere between 25,000 and 30,000 feet. You will want to be approximately 100 feet below this altitude as you approach the tanker. A text indicator above your altimeter box will indicate whether you are 'high', 'low' or 'level' with regard to the proper altitude. Use the aspect angle marker extending from the target icon to plan your approach path and place you in a trailing position relative to the tanker. Note the tanker's speed as well as your closure rate. As a rule of thumb, allow yourself one mile for every 100 knots of closure you need to bleed off, assuming you apply the airbrakes and reduce engine thrust to idle.

Manoeuvring Into Pre-Contact Position

Your goal should be to position yourself approximately one-half mile behind, and 100 feet below, the tanker. You should be on the same heading as the tanker, 'wings level', and with a closure rate of approximately 50 knots. This will allow you to fine-tune your flight path alignment as you complete your approach. If the tanker appears to be sliding away to one side, use the rudders to adjust your course. If your altitude is too high or too low, move the control stick forwards or back slightly. Use only small movements of the stick and rudder to correct your course – a slight tap, allowing the controls to centre between corrections. You will want to drift gradually into position rather than trying to fix a misalignment all in one go. For example, if are slightly off centre to the left, a short tap on the right rudder will cause you to drift slowly to the right. As you approach centre, apply just enough left rudder to stop the drift. Timing and a very light touch are the secret. If you apply too much correction, or wait too long to

counter the drift, you will end up on the opposite side from where you started, or worse, oscillating wildly.

Refueling aircraft follow an elongated 'racetrack' pattern in the sky in order to remain roughly in the same general area. If the tanker initiates its turn at any time during your approach, drop back and wait for its heading to stabilise again before attempting to connect. In addition, if you feel that your alignment is too far off as you near the final approach point, you should also drop back and try again. If you collide with the tanker, not only will it destroy your aircraft and end your mission, but it will deny other aircraft the opportunity to refuel, possibly ending theirs as well.

If you like, you can use the tracking autopilot mode to put yourself in position directly behind the tanker. Be aware however, that the autopilot will position you at co-altitude with the tanker - too high to accomplish the refueling. You will have to lose altitude manually prior to contact.

Once the approach is proceeding smoothly, switch to the standard forward view. Set your throttle at approximately 70 percent of full thrust if you are 'clean', slightly higher if you are carrying external ordnance or fuel tanks, and leave it there. You will now use short taps on the airbrake to slow down as you approach. The idea here is to have enough thrust to allow you to accelerate very slowly if you do not have the brakes extended. Continue to monitor your alignment as you approach, using minute applications of rudder to correct any drift and pitch to correct altitude. Be sure to keep your wings level. As your separation closes to within one tenth of a mile, your closure rate should be down to about 10 knots or so. If everything looks good, the boom operator will inform you that you are 'cleared for contact.'

Making Contact

The altimeter displays altitude in 100-foot increments. Your actual altitude can be as much as 50 feet on either side of the indicated value. While this is fine for your initial approach to the tanker, it is too coarse a reading with which to gauge whether you are positioned properly below the tanker. An excellent visual aid against which to check your altitude is the position of the tanker's wings in relationship to the HUD support frame in the standard forward view. As you approach, the tanker's wingtips should cross the HUD glass just above where the solid frame ends as seen in Figure 7. If they do, you are at the proper altitude. Provided that you do not climb or descend from this point forward, you will end up at just the right spot. As you

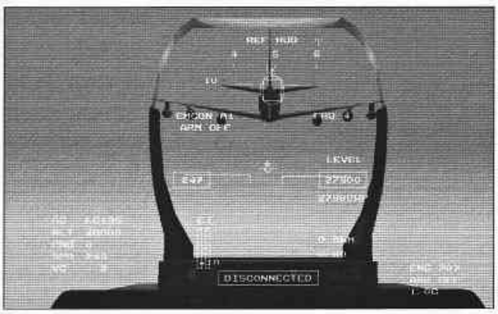


Figure 7

continue to approach, the body of the tanker should slide straight backwards, directly overhead. Correct for any final drift and continue to apply the airbrake in tiny spurts as you close in. Your closure should now be down to just a couple of knots or so.

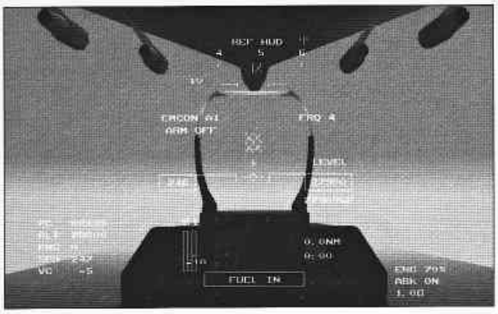


Figure 8

As the tanker looms overhead, look for the 'director lights' under the nose of the tanker. There are two columns of lights. The left-hand set indicate height alignment, the right-hand set indicate fore and aft alignment. Bright lamps, one pair in each column, will illuminate when you are properly positioned. In practice, the lights are nearly impossible to see in daylight, and not much better at night. Using the position of the tanker's wingtips relative to the HUD frame as you approach provides a much clearer reference for altitude and is much easier to spot. At night, watch the wingtip marker lights to gauge the proper altitude.

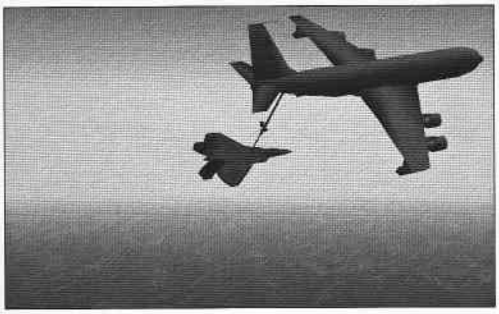


Figure 9

Having made it this far, finding the proper fore and aft position is easy. Time the use of your airbrakes so that your closure rate drops to zero just as the nose of the tanker aligns with the top of the HUD glass. Figure 8 illustrates how this appears in the game. If you stop too soon, release the brakes and allow yourself to accelerate slowly. If you overshoot, tap the brakes a couple times until you slide backward into position.

Your patience and care will be rewarded with a satisfying 'clunk' as the probe slides into the refueling receptacle and the HUD display indicates 'Connected'. At this point, take a deep breath, sit back and relax as the aircraft holds position automatically. (Figure 9) Avoid moving the controls until you are fully refueled.

When refueling is complete, the tanker will instruct you to 'Disconnect and Push 2'. Pull back on the throttle and roll away to the right. Check to make sure that the airbrake is retracted. If you are on a Combat Air Patrol (CAP) mission, switch to radio frequency 2 and notify the AWACS that you are available. If you are on a Strike mission, you are free to continue along your programmed waypoint route. If you have wingmen flying with you, take up a position behind and to the right of the tanker while they refuel before contacting the AWACS or proceeding with your mission.

Refueling the Easy Way

If you feel uncomfortable with manual refueling, allow the autopilot to perform the job for you. This also applies if you are in a hurry because your fuel status is critical. Simply select 'Refuel' from the

autopilot menu, and engage it at any time once you have received pre-contact clearance and have acknowledged the tanker's 'nose cold' request. The autopilot will disengage automatically once you are connected. When refueling is complete, follow the disconnect procedures outlined above.

Part IV Landing

Whether to refuel and rearm, or to complete your mission, sooner or later you will have to land your aircraft. As the old saying goes, 'any landing you can walk away from is a good landing.' While true, you should strive to achieve better. The steps outlined below will help you to achieve perfect landings each and every time under a variety of situations.

Locating the Airfield

During your mission briefing, you should have taken note of where your final destination is located. If your mission requires you to land at a specific airfield, a waypoint will be placed over it. It is always a good idea to study the map and make notes as to the location of the base. In case you suffer damage to your avionics systems, you may have to use dead reckoning in order to reach it. The Instrument Landing System (ILS) mode of your HUD will be preset with the location of your designated airfield. The waypoint caret and data block will provide you with cues as to where you should steer and how far away the airfield is. If you are unclear as to how the ILS HUD mode operates, take a moment to review this information in Chapter 2, Avionics.

Should you need to use a divert airfield, either because you need to rearm and refuel or because you have been damaged in combat, contact the AWACS for vectoring information. If no AWACS is available, switch to radio frequency 1 and request a vector for recovery from an airfield. The nearest available airfield will respond with directions and distance.

Since the ILS HUD is preprogrammed to point to your assigned landing field, you will not be able to use the steering or distance cues when diverting to an alternate airfield. You will, therefore, find it useful to bring up the map and place names display on your TSD. The map display will help you to determine when you are close enough to request landing clearance. If the alternate field is not immediately visible, zooming in may bring it into view. Of course, if there is still some way to go, you may not be able to zoom in enough to see it until you get closer.

Requesting Clearance to Land

When you are within 15 miles of the airfield, select Radio Frequency 1 and request permission to execute your approach. You can choose from one of three different approach patterns: circuit, teardrop or direct approach. Acknowledge your landing clearance by pressing the Y key. The HUD will switch to ILS mode automatically and the padlock view will focus on the airfield. (Figure 10) The Command Flight Path Display (CFPD) will display a series of 'hoops' in the HUD, outlining the glide slope for the runway you have been cleared to land on. Fly through the hoops, and you will be guided to a perfect landing. If you are within 15 miles of the airbase and cannot see the CFPD, check to make sure that you have not inadvertently switched to some other HUD mode, or that you have not disabled the ILS landing display in the Systems MFD.

If the field is busy, you may be requested to 'Join the stack'. This is an instruction to enter a holding pattern until the field is clear. The pattern is similar to the circuit approach outlined below, but flown at a higher starting altitude. With each turn around the circuit, slowly spiral down until you obtain clearance. If the field is out of action due to battle damage, the tower will inform you that 'The airbase is black, divert to …' and provide instructions as to which field you should divert to.

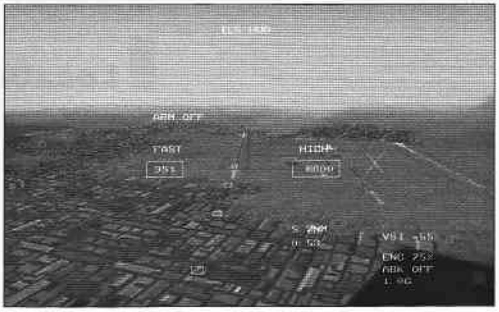


Figure 10

Circuit Approach

A circuit approach is the standard procedure for aircraft landing at a military airfield. If you request a circuit approach, the tower will indicate which runway is in use and instruct you to 'join the left circuit.' Picture the circuit as an elongated rectangular track with the right-hand side of the track positioned over the runway. The first 'turn' is located over the far end of the runway. The short side of the rectangle lies perpendicular to the end of the runway. The left-hand side of the track returns parallel to the runway, and turns back to intersect the glide slope, positioning the aircraft for the turn onto its final approach.

To execute a circuit approach, first fly towards the airfield. You want to end up flying over the runway at 3,000 feet along the right-hand leg of the circuit. This altitude keeps you well above other aircraft that may be using the active runway. As you path takes you over the end of the runway, execute a smooth, banked turn to the left. This places you on the first, or 'crosswind' leg of the approach, heading away from the field at a right angle to the runway. Fly along the crosswind leg for a

moment, and then execute another left-hand turn to place yourself on the second, or 'downwind' leg of the approach. Begin a gradual descent to 1,500 feet and reduce your speed to 300 knots. Fly along the downwind leg until the touchdown point on the runway is about 45 degrees behind you and to the left. Execute another smooth, 90-degree turn to the left onto the third, or 'base' leg of the approach.

Continue to slow yourself down, and as you approach the glide slope, turn left one last time to intersect the glide slope on finals. Your speed, when you turn onto finals, should be between 180 and 200 knots. Notify the tower that you are on final approach and ready to land. If the runway is clear, the tower will grant you clearance to land. Lower your landing gear by pressing the G key and proceed with your final approach. If the runway is not clear, the tower may request that you 'go around'. If so, climb to 3,000 feet and accelerate to about 300 knots. Simply duplicate the pattern and try again.

Teardrop Approach

A teardrop approach is often used when an airfield is close to the forward line of battle. This approach pattern allows aircraft to maintain a higher speed until just before finals, minimising the risk from enemy surface to air missiles. Once the control tower has cleared your approach, aim for a point approximately halfway along the glide slope. As you reach the glide slope, execute a hard, descending spiral turn in order to bleed speed and lose altitude. You should strive to exit your turn such that you flying at approximately 200 knots and, are lined up in the glide slope at approximately 1,500 feet with your nose pointed towards the runway. Drop your undercarriage and notify the tower that you are on finals and ready to land.

Direct Approach

A direct, or 'straight in' approach is the simplest of the landing approaches. Once you have acknowledged your approach clearance, simply fly your F-22 to intersect the CFPD glide slope hoops to perform a final approach. You will want to enter the glide path at about 200 knots.

Final Approach

Once you are on finals, you will want to centre your flight path marker in the CFPD hoops as illustrated in Figure 11. This will ensure that you follow the prescribed glide slope all the way down to the runway. Your speed should now be between 180 and 200 knots. Inform the tower that you are on final approach by pressing the 1, 2 and 6 keys in succession. Do not forget to check your undercarriage. A trio of small circles will appear in the ILS HUD above the centerline

indicator when the landing gear is fully extended. Flying a perfect approach simply to end up scraping along the runway on your belly or, worse still, destroying the aircraft is very embarrassing.

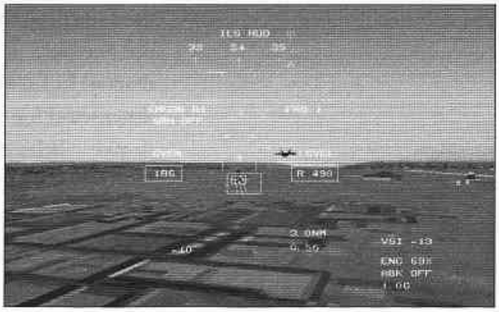


Figure 11

Proper landing speed is between 140 and 180 knots. The precise speed is not critical, so long as you are within the appropriate range. The faster you are within the speed range, and the higher in the CFPD boxes you keep your flight path marker, the farther down the runway you will land. Aim to keep your speed in the middle of the range, and your flight path in the middle of the CFPD corridor. This will give you a cushion against coming in too fast or too slow, or landing too long or too short. Text will appear above the airspeed and altimeter boxes to warn you if you are travelling too fast or too slow, or if you are too high or too low with respect to the glide slope. Even though you are descending, the centerline marker in the HUD should be elevated slightly above the flight path marker - nose up relative to the ground. This is just right, as you want to make contact with the main landing gear first, and allow the nose wheel to drop to the runway shortly afterwards.

The angle of attack needed in order to land at the proper speed is determined by the weight of your aircraft. You do not need to concern yourself with the specific angle required. Simply keep the flight path marker centred in the CFPD hoops and maintain the proper speed, you will automatically attain the correct AoA.

Once your speed is in the appropriate range, control your altitude and rate of descent with the throttle. Check the Vertical Speed Indicator (VSI). If you are on the glide slope, you should be descending at 15 to 20 feet per second. If your are sinking relative to the glide slope, gently apply throttle. Control your speed by using the control stick. If you are too fast, pull back slightly on the stick. These actions are the reverse of what you normally do and adjustments take time to have an effect. Through practice, you will be able to anticipate what corrections need to be made. If your alignment is off centre, use the rudders to correct it while keeping your wings level. Keep your corrections small, using gentle movements of the control stick or rudders. Avoid the temptation to 'chase the needles' as this will generally result in you going too far in the opposite direction.

As you continue your approach, note the Visual Approach Slope Indicator (VASI) lights on either side of the approach end of the runway. These are two rows of lights that serve to provide a visual reference of your alignment on the glide slope. The lights will either be red or white. If both rows of lights are white, you are too high on the glide slope. Red over white 'you're all right.' Red over red, 'you're dead!' You need not concern yourself with the VASI lights if you are

following the CFPD hoops. However, you should familiarise yourself with how these visual cues appear during a 'normal' landing. You may need to rely on them in case your avionics fail due to battle damage, or you need to land at an airfield where no CFPD hoops are available. Developing a feel for the angle of the glide slope as well as approach speed will enable you to land safely, even under the worst of conditions.

F-22 ADF/TAW is extremely forgiving of hard landings. As long as your rate of descent does not exceed 125 feet per second and your wings are level, it is very difficult to damage or destroy the aircraft on landing - although you will probably knock some tooth fillings loose! While such a frighteningly steep landing will not win you any points from the flight instructor, neither will it end your mission in failure.

As you cross the runway threshold, (Figure 12) touch down should be seconds away. Hold the plane in the same nose-up attitude and the ground effect will settle you down on to the runway. Close down the throttle and apply the wheel brakes to slow down. The F-22 does not have thrust reversers or a braking chute. If you need to shorten your roll out, turning off an engine will reduce the amount of idle thrust being generated. Once your ground speed has come down sufficiently for you to taxi safely, turn off the runway onto a taxiway so that other aircraft can be cleared to land.

Aborting the Final Approach

If you find that things are not lining up correctly, abort the landing and go around for another approach. Bring the throttle up smoothly, raise the undercarriage and allow your speed to build back. Gradually climb back up so as to rejoin the circuit once you reach the end of the runway. Avoid hard manoeuvres until you have sufficient airspeed to avoid a stall.

Landing the Easy Way

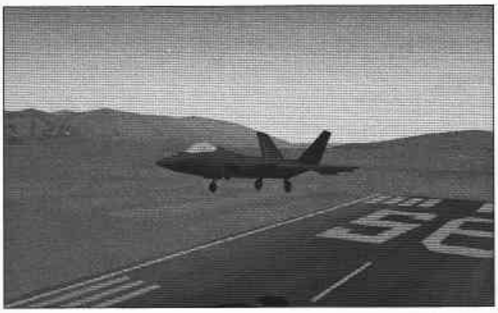


Figure 12

The autopilot can fly the approach and land the aircraft for you if you are uncomfortable with doing so manually. This is an excellent way to 'watch how the pros do it' in order to become familiar with the visual cues involved in landing. Fly the aircraft to within 15 miles of the airfield, and engage the autopilot in landing mode once you have received and acknowledged clearance to land. From this point forward, either sit back and enjoy the ride, or if you like, disengage the autopilot at any time and take over from there.

Part VI Damage and Emergencies

Damage to your F-22 can be either structural (for example the loss of a portion of the wing), or systems related (such as the avionics), or a combination of both. Taking hits from enemy airborne or ground forces will cause random damage in a variety of combinations. Once a system has been damaged, there is no possibility of repair. In addition, damage often worsens progressively until the affected system fails entirely, or other, related systems become affected.

The Systems Check screen, a sub-mode of the Systems MFD displays a number of lighted indicators corresponding to the various components of the F-22's mechanical and avionics systems. Fully functional systems are shown in green. Partially damaged systems are displayed in yellow. When a system is severly damaged or fails entirely, it becomes red. You can also check the Combined Communications & Warning (CC&W) MFD to obtain detailed reports on damaged systems. The CC&W displays damage as percentages of functionality for the various systems. The lower the percentage, the more heavily damaged a system is. Review Chapter 2, 'Avionics' if you are unclear as to how to use and/or interpret the MFDs.

The most serious types of damage are those that affect your engines, fuel tanks, avionics, electrical and hydraulic systems. Severe damage to any one or more of these almost certainly means that you will need to abort your mission. Here is a brief rundown of the various types of damage that may occur, as well as the consequences of each.

Electrical Generator (AC-GEN)

Damage to the electrical generator will create problems for some or all aircraft systems that run on electrical power. These include the radar, avionics and communications systems. A complete failure will cascade into all systems that run on electrical power, leaving your aircraft severely crippled.

AIR-BRK (Airbrake)

If the airbrake fails while it is retracted, reducing thrust and/or executing hard manoeuvres may be the only way you can bleed off excess speed. This will complicate landing and refueling. Watch your speed carefully, especially if you need to dive to deliver your ordnance. If failure occurs while the airbrake is extended, you may be unable to maintain sufficient airspeed without resorting to high throttle settings and/or afterburners. Your operational range will be severely limited if refueling resources are not available. Avoid engaging enemy aircraft as it will be difficult to manoeuvre and escape from a dogfight may prove impossible.

AIR-FRM (Airframe)

This indicates structural damage to the airframe in one form or another. Depending on the severity of the damage, it may be difficult to maintain stable flight. The added drag will restrict your operational range. In addition, your visibility to enemy radar will be increased. Avoid high G manoeuvres and excessive speed as these may worsen the damage.

AUX-POW (Auxiliary Power Unit)

The auxiliary power unit provides backup and starting power to the electrical and hydraulic systems when the main engines are not running. A failure of this system may mean that you will be unable to start the main engines if you are on the ground. More importantly, damage to this system may cascade into a complete electrical failure.

AVI (Avionics)

The avionics are the heart of the F-22, providing you with offensive-targeting capabilities, enemy missile launch detection and defence, navigation and other essential flight data. Damage to the avionics will degrade the performance of, or completely disable some or all of your MFDs. This is a critical failure. Because there are no analog backups to the MFDs, a complete loss of avionics means that you are flying a 'dark' cockpit. Aside from visual reckoning, you will have no way of determining where you are, how fast or how high you are flying. If you are still able to fly at all, land the aircraft as soon as possible.

W-BAY (Weapons Bay)

Damage to the weapons bay doors or ejectors means that you cannot deploy any internally carried ordnance. If you have not

already delivered your ordnance on target, your mission is effectively terminated.

COMMS (Communications)

If the communications system is damaged, you will be unable to contact the AWACS, refueling aircraft, airfields or your wingmen. You may also lose uplinked strategic information on enemy forces and have to rely on your own sensors (IRST and radar) to detect enemy units.

CS (Control Surfaces)

Damage to the control surfaces will make your aircraft difficult to manoeuvre. Severe damage may make it impossible to fly the aircraft at all. Avoid excessive speed and high G manoeuvres, as these will only make the damage worse.

ENG1 & ENG2 (Left And Right Engines)

A failure in one of your engines will result in significantly reduced thrust available to your aircraft. A failure to both engines means that you will have to either glide to a landing or eject. Partial failure of an engine is nearly certain to get worse over time, shutting it down may delay or prevent it from catching on fire. If an engine fire develops shut that engine down immediately. With only partial thrust from your engines, your top speed and ability to execute certain manoeuvres is diminished. In addition, asymmetrical thrust will cause you to yaw towards the damaged side (Total Air War only). Unless you are close to reaching your target, or inbound to your home base, aborting the mission is recommended.

FUEL

Damage to one or more of your fuel tanks will result in a fuel leak. At the least, a fuel leak means that your operational range will decrease enormously. At the worst, a fuel leak can ignite an engine fire. Depending on the severity of the leak and your fuel state when damage occurs, prepare to find a refueling tanker or to land at a divert base. Unless your targets are close to friendly refueling resources, you may not be able to return to base should you choose to proceed.

GUN

Damage to the M61A2 cannon will make it impossible for you to engage enemy aircraft with anything other than missiles, assuming

you have missiles and other damage has not rendered them inoperable as well. For obvious reasons, avoid contact with enemy fighters.

HUD (Heads Up Display)

Damage to the HUD will deny you access to primary flight data as well as some targeting and weapons delivery information. As long as your MFDs are functional, you can obtain flight data and weapons cues from these screens. The Artificial Horizon MFD is particularly useful in providing a backup to speed, altitude and pitch ladder information.

HYD (Hydraulics)

Damage to your hydraulics system will create severe flight control problems. You will need to work the controls continuously in order to maintain stable flight. Once damaged, the system will eventually fail. If the hydraulics fail completely, you will be unable to deploy the airbrakes or the landing gear. Abort the mission and land as soon as possible.

IRST (Infra-Red Search and Tracking System)

Damage to the IRST system will make it impossible for you to lock onto enemy targets without using radar. Assuming that the radar is undamaged, it is quite possible to complete your mission without the IRST, although it may be difficult or impossible to employ stealth tactics.

LAN (Low Altitude Navigation and Targeting System for Night System)

Damage to the LANTI0RN system will compromise the ability to target and deliver laser guided bombs and Maverick missiles. If damage occurs prior to reaching your targets, the chances of destroying them are very slim. A mission abort is recommended. If you are carrying free fall bombs, or you are tasked to an A2A mission, failure of the LANTIRN system is not critical.

NWS (Nose Wheel Steering)

This indicates damage to the nose wheel steering system. You will be unable to taxi your aircraft when you land. Although not modeled in F-22 ADF, you will need to call for a tow.

PRES (Cabin Pressure)

Structural damage or a break in the canopy may result in a loss of cabin pressure and oxygen. Flying at high altitude will aggravate the problem. Avoid high altitude flight under these conditions.

RADAR

Damage to the radar will make it impossible for you to target and launch AIM-120 missiles. IR missiles may still be launched, assuming that there is no damage to the IRST. If the communications systems and avionics are intact, you can still receive enemy threat data through uplinked sources. If the uplinks fail or are unavailable, you will need to rely on the IRST in order to detect of enemy threats.

UND (Undercarriage)

It may be impossible for you to lower your undercarriage if it is damaged. If you succeed in lowering the gear, they may collapse on landing. Prepare to execute a belly landing.

Damage Assessment and Mission Continuation

If you hear an audible warning notifying you of a system failure, you should immediately check the Systems MFD and/or the CC&W to determine which system or systems are affected. Once you know the extent of the damage, you will be in a better position to assess what you need to do next. Some failures will require immediate action, such as shutting down an engine that is on fire. Others, not immediately life-threatening, should be evaluated in terms of how they affect the continuation of your mission. Examples here might be a damaged nose wheel, or a fuel leak, or a weapons systems failure. Clearly, not all of these are mission scrubbers. Regardless of the specific system hit, nearly all damage gets worse over time and often cascades into other system failures.

The original F-22 ADF release is a mission based, rather than a campaign based simulation. Advancing to the next mission requires complete success in the current one – 'almost' is not good enough. If you have little hope of returning to base, it is better to abort and start the mission over. Whether you live or die trying, the result of one mission has no effect on the outcome of any other. Of course, you may choose to continue for the sheer challenge of it, or because you enjoy blowing things up.

With the release of TAW, damage assessment takes on new importance. The inclusion of a campaign engine now means that the

success or failure of any given mission carries consequences for the wider strategic war being fought. If you have fulfilled your mission objectives and are damaged while returning to base, the decision is easy – try to make it home at all costs. If you are reasonably close to your mission targets, and they are of particularly high value, it may be worth the risk to make one strike pass before bugging out. Whether to continue with your mission when you are still some distance from your objective, is a much more complicated decision. While hitting your targets is important, getting yourself and your plane home in one piece is equally important. If damage occurs while en route and the target is still a ways off, continuing may well mean losing the aircraft, and possibly the pilot as well.

You will need to consider the type of damage you have sustained. Damage to the airframe or the control surfaces makes controlled flight difficult and combat manoeuvring nearly impossible. Constant stick movement will be required to keep the aircraft stable and on course. Using the autopilot can help alleviate the burden, but will do nothing for you when the time comes to deliver ordnance or engage enemy interceptors. If you can attack with standoff weapons and have good escort support, you may wish to take the chance and continue your mission.

Your ability to locate and strike your targets is also an important consideration. The F-22 ADF has no backup analog instruments. Therefore, damage to the avionics, sensors or electrical systems will result in the degradation or loss of navigation and flight instrumentation - cockpit MFDs and the HUD - as well as weapons targeting and delivery capabilities. If you cannot fight, or are unable to defend yourself, there is no point in proceeding. Return to base as quickly and as safely as you can. If your weapons systems are operational but you are still a ways from your target, you will need to weigh the value of the target against the possibility that additional systems will fail.

Finally, how long you will need to remain airborne is another consideration when making the decision to continue or abandon a mission. Severe damage, such as an engine fire or problems with the hydraulic system, will quickly result in the failure of other systems. Unless you are nearly on top of the target, ready to release weapons, abort the mission immediately and head for the nearest diversion airfield. Less severe damage may have little affect on undamaged systems. Although the probability of cascading system failures cannot be easily gauged, there is no doubt that the longer you keep flying, the more likely additional failures become.

The importance of bringing the pilot and plane back should not be underestimated in terms of its affect on the success of the campaign as

a whole. Chapter 11, 'Campaigns' will provide you with additional criteria with which you can gauge the importance of particular missions and the effects your decisions will have on the outcome of the larger war.

Low Fuel and Glide Procedures

One of the most common emergencies encountered in F-22 ADF is finding yourself low on fuel. Your options depend on how much fuel remains and the cause of the problem. If the fuel system has been damaged, your problem is much worse than if you have simply been overly aggressive in the use of throttle and afterburner. Regardless of what caused your predicament, reducing your throttle setting is the easiest and most obvious way to reduce fuel consumption. You burn as much as three times more fuel at 100 percent throttle than you do at 65 to 70 percent. In addition, climbing to a more fuel-efficient altitude will greatly extend your available range. At 40,000 feet, your range is more than double what it would be if you were flying at 10,000 feet.

If you are still en route to the target and expect to remain at a considerable distance from refueling tankers or friendly airfields, you will need to consider whether sacrificing the aircraft and pilot is worth reaching the target. If you are returning to base and are still a considerable distance from refueling tankers or friendly airfields, check the 'operational range' indicator in the Systems MFD to determine if you have enough fuel to make it at your current speed and altitude. Assuming you are not threatened by enemy interceptors, climbing to a higher altitude and reducing your throttle settings may provide just enough additional range to get home.

If your best efforts to stretch the remaining fuel prove futile, you will have to attempt to glide to a landing at a friendly airbase, or at the least into friendly territory. Here too, altitude proves to be helpful as the more you have when you start gliding, the more you can trade for airspeed and the farther you can travel. You should drop all remaining ordnance in order to reduce weight (and drag in the case of external stores) in order to extend your glide range to the maximum achievable range.

How far you will be able to glide depends almost entirely on your speed and altitude at the start of the glide and whether or not you need to manoeuvre during your descent. Testing has determined that your best glide performance, at any given altitude, is achieved when your indicated airspeed is between 250 and 275 knots. A dive angle between 5 and 8 degrees below the horizon will be needed to maintain this speed. The exact angle is not important. Simply push the nose down a bit if your speed falls below 250 knots, or pull it up a bit if your speed rises above 275 knots. As a rule of thumb, your glide range will be

approximately 1.7 nm for each 1,000 feet of altitude lost. For example, if you begin your glide at 45,000 feet and 275 knots, you should be able to cover nearly 75 nm by the time you have dropped to 1,000 feet. These figures assume that you have jettisoned all of your stores and that you glide in a straight line. If you start manoeuvring during your descent, your range will be considerably shortened. For this reason, you should align yourself in the direction of your airbase or desired touchdown point before you need to begin gliding.

If you are travelling faster than 275 knots when your engines shut down, simply allow yourself to coast until your speed drops to 260 knots before you push your nose into a dive. How far you can coast before you need to begin your dive depends on airspeed and altitude. Since air density and induced drag is greatest at low altitudes, the higher you are, the farther you will be able to coast. Starting at 40,000 feet and 450 knots, you can coast over 20 nm. By contrast, you will only be able to coast about 15 nm if you start coasting at 620 knots at 20,000 feet.

You may wish to shut down the engines before you flame out. Doing so will provide a few extra moments of manoeuvring power prior to touchdown – power which could be critical in order to line up properly on finals. For example, assume you shut down your engines while flying at 45,000 feet and 275 knots (about 75 percent throttle) when 50 miles remains indicated on the Systems MFD range gauge. Using the formulas provided, you will travel approximately 75 nm during a glide down to 1,000 feet. Re-start the engines and advance the throttle to 60 percent. You can operate the engines for about 2 minutes before flaming out at this throttle setting. Assuming modest manoeuvring, you can easily cover another 20 nm before you completely flame out. Of course, had you not shut down early, you could have covered an additional 50 nm or more before initiating your glide – at least 2.5 times farther during powered flight. Which strategy you choose depends on how close you are to a friendly airbase. If you need to stretch your range to the absolute maximum, stay as high as possible for as long as possible. If you think you can glide the rest of the way to the base, shut down the engines and save the last bits of fuel for your final approach line up.

One final note. If you have sustained fuel system damage, you need to be aware of two things. First, there is no advantage to shutting down your engines early. If you have a fuel leak, it will simply drain out during your glide. Climb to a more fuel-efficient altitude and fly for as long and as far as you can, beginning your glide only after you have flamed out. Second, the fuel range indicator in the Systems MFD may over-report your achievable range. As noted earlier, if you sustain fuel system damage, immediately begin planning on where and how you will refuel.

Coping with Structural Damage

Damage to the airframe or control surface will force you to apply constant correction to the flight controls in order to maintain stable flight. If the autopilot is functional, you may be able to engage it to alleviate the problem. The heading autopilot mode is preferred as it gives you the most flexibility in choosing your course. If the autopilot is non-functional, or will not remain engaged, you can try the following to alleviate the effects. If your joystick is equipped with trim wheels, you may be able to adjust them so as to be able to maintain level flight with a minimum of stick movement. If not, you can try re-calibrating your joysticks in order to simulate holding them off-centre. First, you will want to climb to about 10,000 feet or so in order to have a decent cushion of altitude. Next, find the stick position that most closely allows you to fly level. For example, if the plane is diving and rolling left, you will need to hold the stick pulled back and to the right. Now comes the tricky part. You will need to move the controls to the opposite position, mirrored across the centre, then press **ALT - C** to re-calibrate. For the example given above, you would move the stick forward and to the left. When you release the joystick, it will act as if you have it pulled back to the right. This may take a few tries to get it right, but it will make a big difference in how easy it will be to control the plane once you have it set.

Coping with Engine Failure

When one or both of your engines are damaged, the total amount of thrust available is reduced. The F-22 ADF is quite capable of operating on one engine alone, although top speed and manoeuvrability will be compromised. As a consequence, avoid close contact with enemy fighters. Also avoid continuing to use a moderately damaged engine if possible. Damage will grow progressively worse until an engine fire or some other catastrophic failure occurs. If a fire does occur, shut the engine down immediately and start looking for a place to land. Continuing to operate a burning engine will certainly result in an explosion, destroying the aircraft and killing the pilot. Even with the engine shut down, your chances of remaining airborne for an extended period are greatly reduced once a fire has occurred.

TAW now models the effects of asymmetric thrust when one engine is shut down, or is producing less thrust. The effect is more pronounced the greater the thrust differential is between the sides and causes the aircraft to yaw into a turn towards the side with less thrust. You can compensate for this by applying opposite rudder. If you have a long

way to fly, you can try re-centring your rudders in much the same way as described above for the joystick. Simply push on the side you are turning towards until you have roughly doubled the amount of yaw. When you hit ALT+C and release the rudders, you should be flying straight once again.

Coping with Hydraulic Failure

In the case of hydraulic failure, the aircraft will tend to pitch and roll continuously in unpredictable directions. Correcting this problem with trim or re-centring is impossible. As damage worsens, flight control will deteriorate to such a severe extent that ejecting may be the only option. At the first sign of hydraulic problems, head for a divert airbase immediately. Things may not seem be too bad at first, but they will get a lot worse the longer you wait. Once the hydraulic system has fallen below 50 percent, you may only be able to apply the airbrake once. Worse still, you may be unable to lower the landing gear. Avoid operating the airbrake, landing gear or weapons bay doors in order to conserve pressure as long as possible. If a friendly airbase is nearby, cut power and try to get below 250 knots without using the brakes, saving what pressure remains to lower the gear. If you cannot lower the landing gear, you will have to execute a belly landing.

Emergency Landings

As noted earlier, the F-22, as modeled in ADF and Total Air War, is extremely forgiving of rough landings. You must be below 285 knots in order to lower the landing gear, however you can land on a runway at that speed. Even at such a high speed, you can safely land at a descent rate of up to 125 feet per second! This is a frighteningly steep and fast landing – comparable to jumping off of a 20-story building! Definitely not recommended. Any deviation from wings level touchdown may cause your aircraft to spin out of control, possibly flipping over and crashing.

If you must make an emergency landing, almost any flat surface will do in a pinch – roads are great, though any large open area works fine. Avoid hills, canyons, water, and any area where buildings or other objects might be in the way. Before landing, jettison all remaining ordnance. With your gear down, descend on as normal glide path as you can towards your selected landing point. You will want to make your approach at 150 knots, and descend at about 15 to 20 feet per second. The VSI located on the ILS HUD will help you maintain the proper glide path. If the HUD is not available, you will have to rely on your best guess and your experience during previous, normal landings. As you are about to touch down, make sure your wings are level, pull back slightly on the stick and cut power. You should settle

gently on the main landing gear. Shut down the engines and apply the brakes.

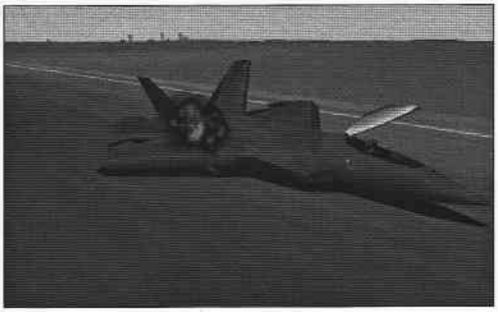


Figure 13

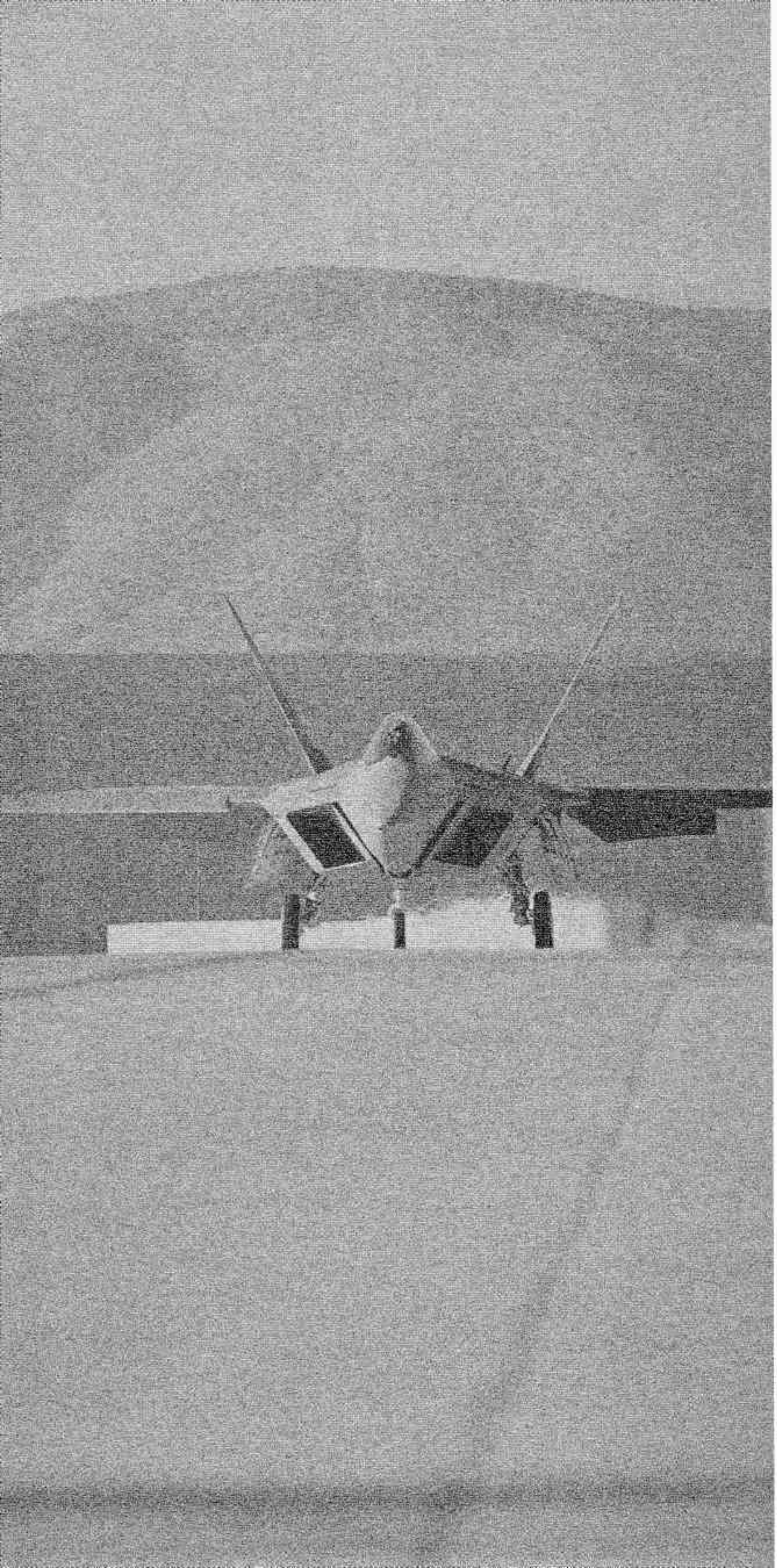
If you cannot lower the landing gear, due to hydraulic or other failures for example, you will have to execute a 'gear up', or belly landing. Before attempting this procedure, make sure that all remaining ordnance has been jettisoned. You do not want a bomb or a missile to explode when you hit the ground. Your approach should be very similar to a normal landing, however the limits on speed and vertical descent are more demanding. If your speed exceeds 200 knots, or your descent is greater than 30 feet per second, the aircraft will explode on contact. Even if you survive the initial contact, your aircraft may explode as it skids across the ground if you touch down close to the maximums. Be sure to shut down your engines immediately upon contact with the ground in order to minimise further the possibility of fire, explosion and the destruction of the aircraft. Landing on a runway, road or other smooth surface provides the best chance for walking away from a belly landing. Landing on open terrain is possible, just be sure you touch down as slowly and as smoothly as you can (Figure 13).

Chapter 4

PERFORMANCE

AIRCRAFT

MISSILES



CHAPTER 4

Chapter 4 Performance

The F-22 has been designed to enable the USAF to prosecute its doctrines of air power into the 21st century. Primarily that of the counter-air campaign, with air control objectives to deter, contain or defeat enemy air forces as the need arises. One of the objectives for air control includes that of air superiority, that is the ability to carry out the doctrines of anti-surface and strategic campaigns without prohibitive enemy interference. A decisive factor in the achievement of air superiority is the qualitative balance between the aircraft of the opposing air forces. Other things being equal, these objectives can be met by fielding an aircraft whose overall technology and performance is superior to that of the enemy. That has clearly been the driving force behind the development of the F-22. As General George Kenny, the US Pacific Air Commander during W.W.II said, "Having a second best Air Force is like having a second best poker hand," it can be used for little more than bluff. However, this is not the whole story. History has proven, and recent conflicts have reinforced the fact, that pilot quality and training have an impact on the outcome of air campaigns. Having the hardware to do the job is not enough. As Randall Cunningham pointed out in his paper on Air-to-Air Tactics "The key to success in air-to-air combat is the pilot, his ability, training..." and he went on "...and concentration must be directed to maximum performance". Pilots must not only be well trained, but well informed with up to date intelligence on aircraft performance. The objective of this chapter is to provide you, the F-22 pilot, with that information.

To survive in the extremely hostile environments you will encounter in this simulation, driving the most deadly fighter in the world will not be enough, you will need to be armed with information on the relative performance of your aircraft and all those you expect to meet in combat. You will thus be able to identify what regions of the flight envelope are most advantageous or dangerous to you. Information you will need includes the relative enemy aircraft performance, in terms of speed, turning ability, corner velocity, climb rate and many other characteristics that will depend upon altitude and fuel or weapon load outs. Before you take your F-22 into combat, you need

to know what it is really capable of in order to exploit its strengths. Even so, the ability to fly your aircraft into a position where you can remain safe while you kill your enemy is not a simple task. You have the F-22 at your disposal. It has some outstanding performance capabilities that include stealth, super-cruise and enhanced manoeuvrability. Let us examine them in turn.

Part I Aircraft

Stealth

Your F-22 represents the state of the art in low-observable signature reduction technology. The performance advantage of low radar cross section is achieved through the degradation of enemy systems and increased effectiveness of defensive systems and counter measures and thus survivability. Combined with the use of stand off weapons and sustained supersonic speed the element of surprise is also further enhanced. Your F-22 is already a formidable adversary with the ability to employ stealth and high closure rates to achieve rear aspect launch parameters within your target's no escape zone before leaving undetected, and more importantly, before retaliation is possible.

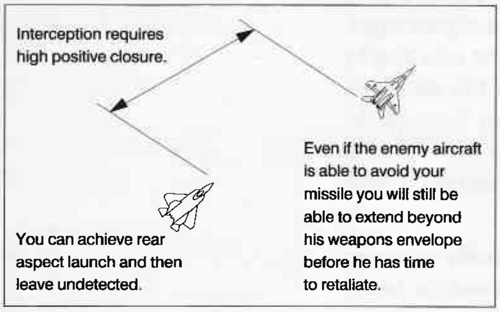


Figure 1

The techniques required to achieve those ideal conditions are explained in the chapters on air to air weapons and air to air combat and will not be discussed further in this section. However most pilots will from time to time, find themselves in a situation that is not ideal, when detection can not be avoided and more traditional tactics are required. At those times you will need to know how to employ your F-22's speed and manoeuvrability to your best advantage (Figure 1).

Super Cruise

Mission success in F-22, just as in the real world, depends upon your ability to minimise the risks. One of the ways in which the design of the F-22 helps to achieve that objective, is its high sustained combat cruising speed. As a combination of the enormous thrust, courtesy of its two Pratt and Whitney F119-PW-100 turbofan engines and other aerodynamic advances, the F-22 can sustain supersonic speeds without using Afterburners. A high combat cruising speed makes your aircraft much less vulnerable to attack because it is more difficult to surprise or to intercept. Surprise and interception depend, among other things, on the ability to achieve high positive closure rates. That

is closure rates at least high enough to achieve weapons parameters before bingo fuel, and ideally high enough to achieve weapon employment prior to detection. That is why the performance capability of sustained supersonic speed, dramatically reduces the risk, and increases your offensive potential and lethality (Figure 2).

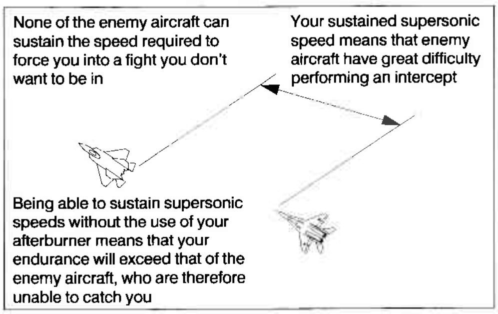


Figure 2

When engaging other enemy fighters, surprise is the key factor. It has been shown from historical records that 80 percent of aircraft shot down in combat were unaware of their attacker. The only fights you want to be in, are those where you are the only pilot aware that a fight exists. Ideally your 'Fights On' call to the enemy will be weapon employment from within the no escape zone, when the risk of retaliation is minimal. The ability to achieve that objective through stealth has already been discussed, but speed is an important variable in the equation. Surprise depends upon reducing the time it takes to manoeuvre to within weapons range. The longer that takes, the more chance there is that you will be discovered by enemy threat warning systems. So high positive closures are vital for maintaining the element of surprise and maximising your missile envelope. Just as offensive potential, or lethality, is enhanced by a high sustained combat cruising speed, so too is your flexibility. During a mission, you will be flying waypoints according to your mission plan, along a route chosen because you anticipate a safe undetected ingress to your target. Should you detect enemy aircraft en-route, you can alter your plan by changing your waypoints, and thus remain undetected to the target. Once detected, you can remain almost impossible to intercept, by maintaining high speed. The ability to maintain that high speed at military power increases your combat radius and permits a high degree of flexibility in your mission.

Conversely, your passive survivability can be dramatically enhanced by the ability to avoid being surprised. Your F-22 is not the fastest aircraft in the arena, in terms of top speed, but it will fly at supersonic speed for longer periods of time than aircraft that need to augment their thrust with Afterburning in order to go supersonic. Afterburning involves spraying extra fuel into the exhaust gasses to increase thrust, but that dramatically increases fuel consumption, and therefor reduces combat endurance or persistence. So with the almost impossible intercept geometry and small missile envelopes created by your high cruising speed, few of the aircraft you will encounter can force you into a fight you don't want. It means that in most cases, the decision to engage is yours. You can choose to fight when the tactical situation is favourable and to leave when it is not.

The things we have been discussing are known collectively as Combat Persistence. Having both the speed and endurance to dictate the time

and place for the fight and once engaged, having the ability to stay in the fight longer than your opponent, means that in many cases your enemy will be forced to break off first. In close combat breaking off first will make your enemy extremely vulnerable, more importantly, awareness of these factors means that you will be able to avoid engagements where you may be placed in the unfortunate position of not having enough fuel to finish the fight and make it home safely.

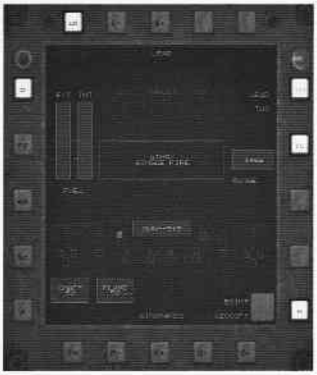


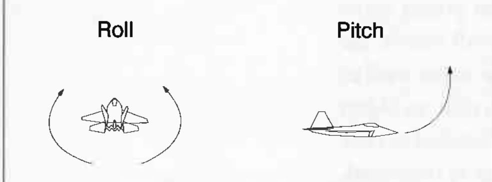
Figure 3

These ideas are very important and can be exploited in F-22. You can learn to achieve maximum Combat Persistence and manage your fuel consumption by intelligent use of the throttle. You can do this by monitoring the data available on the systems MFD. You can access that display using the zero key on the numeric keypad (Figure 3).

From there you will be able to adjust your throttle setting to maintain the required positive or negative closure while ensuring that you still have the range available to reach safety. Generally speaking, your best range will be achieved at higher altitudes and lower speeds. The best speed for maximum range in the F-22 is 250 knots, as seen in the HUD, with whatever throttle setting will allow you to sustain it. Of course, such a low speed is not practical for combat purposes and so a higher cruising speed is normally chosen.

Energy Manoeuvrability

The manoeuvrability of an aircraft refers to its ability to change its position and orientation in space. Aircraft that can change their position and orientation by climbing, accelerating, turning, pitching or rolling more rapidly than another are said to be more manoeuvrable. The sort of Basic Fighter Manoeuvres (BFM) employed during air combat, require you to fly through a variety of climbing, diving, rolling and turning manoeuvres. Your aircraft will therefore change its speed and altitude during a fight in a fluid and continuos manner. The way in which that is done is almost entirely within the pilot's control. However the changes in speed and altitude that occur will also have an effect on other aspects of your aircraft's manoeuvrability. For instance, because the ability of your aircraft to roll, pitch up, and generate lift for turning, all depend upon the aerodynamic forces generated by its motion through the air, speed has a profound affect on those things (Figure 4).



The performance of the F-22 in terms of its ability to perform manoeuvres depends upon its speed and therefore upon its energy

Figure 4

That is, the way the pilot controls his altitude and speed, affects his ability to make angular changes in terms of rolling and turning. For that reason these

ideas need to be discussed together, however talking about speed and altitude at the same time can be unwieldy, even clumsy. Fortunately, speed and altitude are physical attributes that can be described using another single term, energy. An aircraft's manoeuvrability is so closely related to its energy state that the two need to be considered together. Exactly why that is so, will become clear as the discussion unfolds. For the time being, accept that the concept of energy and its application in air combat is vital to success. Indeed, when talking about aircraft manoeuvrability, the idea of energy is so important that any time spent gaining a complete understanding will be very well rewarded. The depth of the explanation provided here reflects this.

Energy

Energy is a concept used to describe the condition of your aircraft. So when your aircraft displays certain types of behaviour it can be described as having energy. As a tool, the concept of energy can make the behaviour of an aircraft very much easier to understand and describe. If we refer to energy instead of the things that cause it to have the energy in the first place we can obtain a deeper insight into good aircraft handling. Energy is a very broad notion, we say that an object has energy for various reasons, because it is moving, because it is high, or because it is hot or rotating about an axis. Those are different types of energy, and as such can be categorised and named, you are probably already familiar with several types. It can sound very technical to refer to something like thermal or electromagnetic energy, if you are not technically minded, those descriptions can be daunting. The important thing to remember is that they are just labels, nothing more than names. In terms of manoeuvrability, a pilot is mainly interested in the speed and altitude of his aircraft. Therefore when he talks about energy he is talking about two particular types, Kinetic and Potential energy. Of course other types of energy are of interest to a pilot, thermal, electromagnetic and rotational energy for instance, but they have less direct influence on manoeuvrability. Those are the names, but what do they mean?

Kinetic energy is the name given to the energy possessed by an object in motion. An aircraft that has some speed is said to posses some Kinetic energy. It's as simple as that! The faster the aircraft travels, the more energy it is said to possess. Potential energy is the name used to describe stored energy. One way of storing energy is to raise an object above the ground. When the object is lifted, energy is required to raise it. When the object falls, it gains speed and the energy is recovered. While it was in its high position it had the potential to fall and gain speed, it had potential energy. Similarly an aircraft that has altitude is said to possess potential energy. The higher the aircraft is, the more energy it is said to possess, because it will be able to gain more speed

when it falls. At this point you may be thinking that things have hardly become any simpler. Initially we had speed and altitude, and now we have simply replaced them with two types of energy. However thinking in terms of energy allows us to perform a trick that does simplify things a great deal.

Normally when you want to add quantities together it is important to ensure that they have the same units. So for example trying to add apples to oranges is not a valid thing to do, because at first the answer seems meaningless. However two apples plus two oranges can make sense, only if you consider using a new system of units called fruits, when the answer can then be four fruits. In the same way, adding speed and altitude together is fine, providing you think in terms of the energy. That this is a reasonable thing to do can easily be demonstrated. For example, if you throw a ball vertically up into the air, you give it an initial amount of energy in terms of speed. As it gets higher it slows down, eventually it changes direction, and reaches your hand again at the same speed at which it started. During its entire flight the speed and altitude were changing, as it got higher it got slower, as it fell again it became faster. However at any moment during the ball's flight, the speed and altitude together amounted to the same quantity of total energy. The amount of energy just represents the combination of speed and altitude. What we have done is added the speed and altitude together in terms of the amount of energy in each. We have forged a link between speed and altitude using a tool called energy. We have discovered that two seemingly separate quantities are in fact intimately related. The ways in which this relationship is so vital in air combat can now be considered.

For the fighter pilot, the concept of kinetic and potential energy allows him to describe the combined effect of speed and altitude together. When you fly your F-22 the overall energy status is the sum of its kinetic and potential energy and that will depend upon its speed and altitude. Just like the ball in the example, an aircraft can trade altitude for speed by diving. The higher it is, the more potential energy it can convert to kinetic energy and the more speed it can gain. If the pilot climbs he will lose speed but gain altitude, which can be converted back to speed by diving once again.

The way in which speed and altitude are converted back and forth in this way is called 'Energy Management'. The combination of an aircraft's speed and altitude is referred to as its 'Energy Status'. It is possible for two aircraft to have the same energy status even though their speed and altitude may be different (Figure 5).

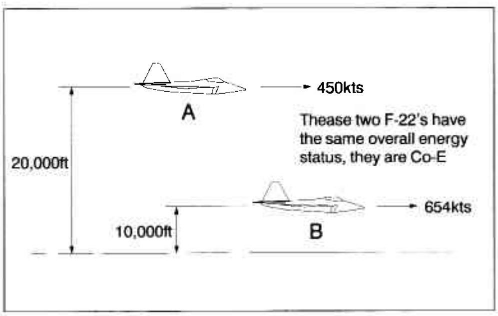


Figure 5

These two aircraft are at different altitudes and speeds but their total energy status is the same. The total energy of an aircraft is represented by the capital letter E, so in this case the two aircraft are said to be Co-E. Being Co-E means that if in this example the low fighter climbed to 20,000ft his speed would bleed to 450 knots or that if the high fighter dived to 10,000 feet his speed would increase to 654 knots. That means that they have the same amount of total energy. It means that if they both zoom climbed, they would reach the stall at the same altitude.

Now you will begin to see the advantage of talking in terms of energy instead of speed and altitude. In this example, comparing two aircraft would require both the speed and altitude for each aircraft, that is four quantities, and it would in any case be difficult to interpret. However by combing those quantities and thinking in terms of the energy, it was easy to see that the two aircraft were in fact identical in that respect.

So, we have arrived at a way of describing speed and altitude in terms of a new quantity called energy. That allows us to combine the speed and altitude together into a single quantity that expresses the sum of both, quite a neat trick. Because fighter pilots often want to compare aircraft of different types, they refer to something called the specific energy for an aircraft. That is just the aircraft's total energy divided by its weight. That provides a measure of the energy per pound and is much more useful because it allows us to compare aircraft of different weights.

Specific energy is called Es or E with the subscript s, to indicate the difference between total energy and specific energy and is pronounced 'Ease' by fighter pilots. So in terms of being able to climb to a greater altitude, or to the same altitude at a higher speed, more Es can already be seen to endow a fighter with more manoeuvrability. You might say that an aircraft with more Es has more options for converting between its potential and kinetic energy. It will be able to convert air speed to altitude more readily, you might say that it was more energy manoeuvrable.

For similar aircraft an Es advantage would also translate to manoeuvrability in the sense of turning ability because it will have more energy to burn pulling high Gs and thus turning more quickly. So energy can be translated directly to angular manoeuvrability. That brings us to the next step, combining the idea of energy manoeuvrability and angular manoeuvrability, into a simple graphic format known as the Energy Manoeuvrability diagram. Before we take that next big step however, we need to fill some gaps. When we look at the Es for an aircraft, we only know the value for an instant in time. However, the Energy State of an aircraft is changing all the time. External influences, like thrust and drag, cause this change. So far we

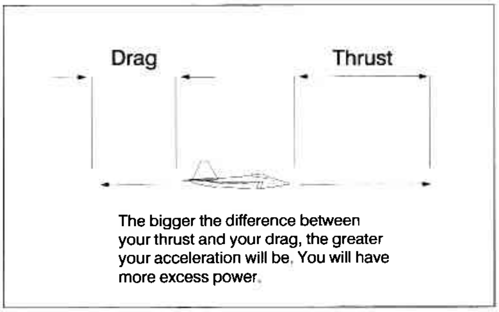


Figure 6

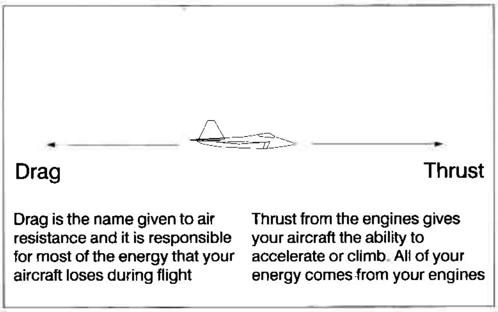


Figure 7

have ignored thrust, drag, and atmospheric changes that would have an influence on the amount of energy. We now know what energy is and how it can be combined but where does it come from, and where does it go? (Figure 6).

The thrust from the engines provides an aircraft with its energy. When the thrust is greater than the drag, the aircraft accelerates and gains kinetic energy that can be converted to potential energy at the pilot's discretion. Drag is the name given to air resistance. The aircraft's energy is dissipated by drag. During normal flight the F-22's engines can overcome the drag with relative ease and energy is not a huge concern to the pilot who can increase his speed and gain energy even while climbing. In order to gain speed rapidly, a pilot can unload to zero G, thus reducing drag and allowing gravity to assist. When an aircraft manoeuvres however, the drag is increased to the point where the engines cannot overcome the energy loss produced by drag. During combat, fighter aircraft execute hard turns and because hard turns produce large amounts of drag, they lose energy. When a pilot pulls hard turns energy is lost, and since low energy states are less desirable, it is of vital importance to the combat pilot that energy is not wasted and that he understands something of the rate at which changes in his energy state occur (Figure 7).

So, we do not just convert energy from one form to another by trading our altitude to speed and our speed to altitude as the circumstances of an engagement dictate, we also lose and gain energy by virtue of the thrust and drag. When an aircraft has enough thrust available to gain energy we say that it has excess power. That means power above that needed to overcome drag, and useful for acceleration. However when we want to make comparisons between different aircraft, we need to consider the weight of the aircraft once again, just as we did with total energy. That is because the same excess power will produce less acceleration on a heavy aircraft than on a light one, so that the lighter aircraft will be more manoeuvrable. We need to take the weight into account, just as we did with the Es, by dividing the excess power by the weight we have a quantity that represents the excess power per pound and is called specific excess power, or Ps (pronounced 'Peas'). Now we have a much more valuable tool for considering the manoeuvrability of two aircraft. The Ps provides us with a measure of the rate at which an aircraft gains or loses its energy. Having more Ps means being able to accelerate or climb faster, that is the ability to gain energy more quickly, that is energy manoeuvrability. And that, by

virtue of the changes in speed and G load that can be made to occur as a result, can be translated directly to angular manoeuvrability.

Energy Management

During a manoeuvring engagement a pilot is able to control the way in which his energy state is distributed between speed and altitude and the rate at which he is able to gain or lose energy. He can lose energy by flying in that part of the envelope where he has negative Ps, the payoff is that in a level turn, the area of the envelope associated with negative Ps produce high turn rates and smaller turn radii. A pilot can gain energy by flying in that part of the envelope where he has positive Ps, and again the price to be paid for the gain in energy is lower turn rates and larger radii. Those things all happen in a dynamic and fluid way during the course of an engagement. A pilot's current energy state or Es, have a strong influence on the type of manoeuvre that will be executed in response to his situation. Let us look at an example of energy management in action. Consider the position shown in Figure 8. At time 1 the attacking pilot has a high closure rate of 150 knots and as the defending pilot executes a break turn, the attacker is in immanent danger of an overshoot.

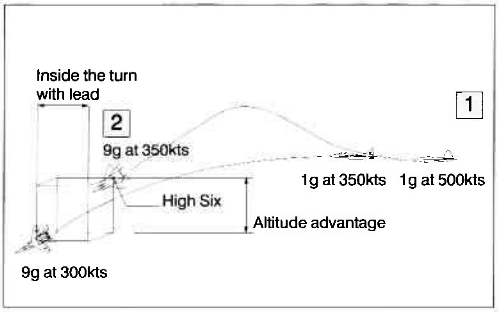


Figure 8

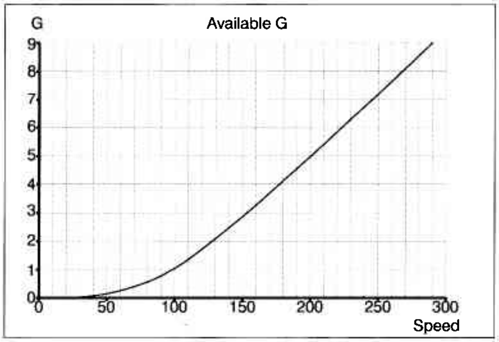


Figure 9 - Available G

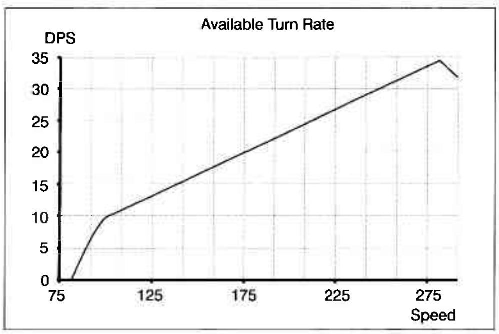


Figure 10 - Available Turn Rate

In order to avoid the over shoot, this pilot could pop the boards in order to reduce his airspeed, and let the airbrakes do the work. He could haul the throttle back to reduce thrust and reduce his airspeed, but those things represent very poor energy management. They give away energy that can not easily be recovered. What is worse, is that if he reduces his energy too much, as his speed drops below corner he will be able to pull less and less G and his turn rate will drop and he will lose angles.

Figure 9 shows how the G available for turning the aircraft drops dramatically with speed. Figure 10 shows how the turn rate in Degrees Per Second (dps) drops as the air speed drops.

However in this case the energy does not need to be thrown away, it can be saved and converted to angles, that is to pull your nose around the circle. Good energy management simply involves a process of controlling your Gs, speed and altitude in a way that conserves your

energy. In this example good energy management would require this pilot to pull up into a hi yo-yo and avoid overshooting by pulling his velocity vector out of plane and thus reducing its component in the defending aircraft's plane of motion. The increase in altitude helps to reduce his speed and because he is above corner velocity that will also increase his turn rate and reduce his turn radius. The defender will pull into a nose low turn in an effort to maintain his speed and turn rate, but will lose speed also, just not as quickly. The attacker will suffer greater speed loss as his speed reduces over the peak of the yo-yo to below corner velocity, because as we will see later, that is where he has the maximum negative Ps. The attacker has avoided the overshoot by changing the direction of his velocity vector and reducing its magnitude. That means that closure has been reduced because firstly his speed has been reduced, and secondly the direction of his motion, or the geometry has been altered. In terms of the energy changes, as his speed dropped over the peak of the high yo-yo, he was increasing his turn rate at the expense of greater drag induced loss of energy. He was spending energy on angles, and holding some in reserve as altitude. He simply transferred the energy held in his speed for altitude and traded some for angles to gain the high six. In this case the decision to pull high would, for a good pilot, have been instinctive, because understanding energy management makes the choice of manoeuvre perfectly natural. The use of a high yo-yo was dictated more by the energy status than the initial geometrical position. For that reason, good BFM is impossible without good energy management, and in air combat good energy management is everything!

Managing energy with the Flight Control Stick

Of the flight controls available to the pilot, the most important for energy management is his Flight Control Stick (FCS). It can be as simple as juggling your altitude and airspeed in order to maintain an optimum turn rate, or flying in a part of the envelope where you have zero Ps, that is your sustainable turn rate, in order to avoid losing energy. During an engagement you must do those things, and learn to control your airspeed with your FCS and not the throttle or airbrake. You can control your air speed with the FCS by changing your altitude, using climbs, yo-yos and other vertical or out of plane manoeuvres. Those are good techniques because they transfer energy from one form to another, use of the other controls like the throttle or air brake simply waste energy.

A slow fighter with height may have the same energy status as a faster opponent at low altitude. However, speed and altitude are not equally desirable in all situations. Given the choice between speed and altitude

when entering an engagement, there are advantages in choosing speed. The reason for this is that with speed you have more options due to the fact that it is possible to decelerate in an emergency more quickly than you can accelerate. With speed you will be able to avoid enemy missiles or leave the engagement altogether if you choose. However if a turning fight is inevitable and you need to lose kinetic energy in order to fly at the speed that maximises your aircraft's manoeuvrability, you will be able to do so quite rapidly. In a close combat situation it is more desirable to have to lose kinetic energy by trading some for altitude, and dissipating some in a hard turn, than it is to be forced to gain it by unloading and thus making yourself vulnerable. Also as a last resort, you have the airbrake. Of all the methods available for reducing speed, pulling high G gives an angular return, climbing stores energy for later, but use of the airbrake gives energy away for no gain. If you find yourself needing to use the airbrake, you have probably already made an expensive mistake, the airbrake is a last resort. However, if you enter a fight and your speed is embarrassingly high, the airbrake may be the best way to reduce speed to your corner velocity as quickly as possible, but in a hostile environment an extension may be a more prudent manoeuvre.

As aircraft have developed in power and performance it might be thought that energy would become less of a worry to fighter pilots. During the second world war altitude and speed was everything. As engines became more powerful, lost energy could be recovered more quickly. However, as fighter aircraft have evolved, so have the weapons. In the arena of modern air combat, a low energy status quickly converts a state of the art fighter worth millions into missile bait. A low energy status can reduce your escape options to the point where you may become trapped in a fight that you cannot win. In order to avoid that situation you must employ methods that conserve energy. To do that you need to be aware of the areas in your flight envelope where you have excess power, that is more thrust than drag. Firstly though, let's pause for an often-used analogy. A word of caution though, because analogies can be dangerous. False similarities can seduce our imagination and fool us into seeing things that are not there, clouding our vision instead of clearing it. However, used as in this case, to clinch an already reasonably complete argument, we can proceed with out fear. The analogy referred to is the comparison between energy and money. The reason for making such a comparison is the hope that by association with an already extremely familiar and comfortable notion such as money, the concept of energy will become easier to understand.

A Useful Analogy

Energy can be compared to money, speed being cash in your hand, while altitude is money in the bank. You spend money by doing

anything that causes your speed and altitude to be dissipated, and you earn money by accelerating or climbing. So using that analogy, it can be seen that money can be transferred from the bank to cash in hand with no loss. That is you can dive to gain speed. You can transfer money back into the bank, in the same way you can climb again, losing speed but gaining altitude. Having altitude is just like having money in the bank because you can convert it to cash again as required. In each case you always have the same amount of money, or energy. You simply move it from one form to another. That is what you can do with energy when you have it, but we know it is more fun to spend our money than to earn it, so let us consider wise expenditure in more detail.

Of course you need to earn money before you can spend it. Similarly you can gain energy by using the excess power of your engines to accelerate or climb. You can then spend your energy by pulling high G loads to turn more rapidly and thus gain angles while losing altitude or speed. You spend money to gain angles, and that's a very important concept, energy allows you to generate turn rate, it buys you angles. Unfortunately all types of energy transfer also involve a certain amount of waste, but good energy management is about getting the best value for money, or the maximum manoeuvrability for least cost in energy. What makes this complicated is that pulling hard turns doesn't involve a fixed rate fee. The cost in energy depends upon the speed, altitude and G load used when you do it. However, not all angles cost the same amount of energy, you can even gain angles for free if you know how to do it.

Getting your angles for free can be an important tactical expediency, particularly at the start of a fight, when you can set yourself up with an Es advantage that can last through to the kill. This is done by allowing your opponent to pay hard cash for his angles, spending his energy to gain position. As he spends more energy, his cash will run out and he will get less and less for what he has left. As his money runs out, his turn rate will drop to a very low level and eventually he will be forced to earn money and give his positional advantage right back.

Something For Nothing

The secret to getting free angles is simply to turn at zero Ps. That is turning at constant speed. In practice you can do that in two ways. Depending upon the configuration of your F-22 you will see later that it is sometimes possible to sustain the G limit. That is to continue turning at 9G (point B in Figure 12 or above 400 knots in your F-22 with a clean configuration at Sea level). You can stay at that point in the envelope, and maintain full aft stick. If you do, you would be able to easily sustain a high energy level but you would have a modest turn rate and a larger turn radius. The idea is to wait until your opponent

has committed to spending his energy before you commit to spending yours. You want to tempt your opponent into an energy low situation before converting your energy advantage to altitude, using the vertical to gain the positional advantage. There is a risk in this however, because if you hold this situation for too long your opponent will simply turn inside you and spend all of his energy for a shot. If you give away a shot, you have waited too long. Ideally you want to establish a small energy advantage that will enable you to continue turning at a high rate just a little longer than your opponent. The second method involves sustaining a higher turn rate and smaller turn radius by flying at a point higher up on the Ps=0 curve. A good question at this point would be what speed to sustain? The answer is to try and sustain your Corner Velocity on the Ps = 0 curve and we will shortly explain what that means. However this method involves a good deal of self-control in order to avoid the temptation to pull too hard on the stick. The advantages are much the same, and the objective is once again to tempt your opponent into getting slow first, to spend his energy in the hope of getting a weapons solution that you will ensure never quite materialises.

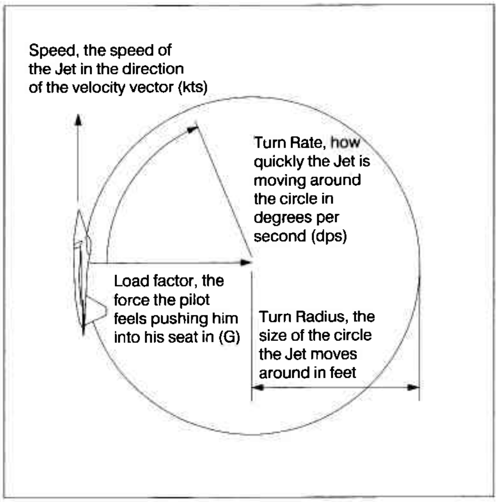


Figure 11

The last thing we need to consider is exactly how energy can be converted to angles. Angular manoeuvrability is the next big step before we can pull the whole argument together into one combined view of angular and energy manoeuvrability and the graphic methods used to interpret those ideas.

Let us begin by considering an aircraft's turning ability. The main factors affecting an aircraft during a turn are shown in Figure 11. For any given speed and load factor, there will be a specific turn rate and turn radius. However in a dogfight you are not interested in the specific values for turn rate and turn radius, your goal is to achieve the highest turn rate and the smallest turn radius.

The relationship between speed and load factor dictates that slower speed and higher load factors produce higher turn rates and smaller turn radii. The simple answer would appear to be for you to pull as much G load as possible and go as slow as possible.

That's fine in theory, but there is a slight problem. You can go as slow as you like, but you can never pull as much G as you like. When you have the speed to generate as much lift as you want, you are bound by the G limit imposed by the flight control computer and ultimately by the structural limits of the aircraft and the physical limits of the pilot. This is referred to as being G limited. Structurally, most high

performance aircraft are designed to withstand a maximum load well in excess of 9G. Loads significantly above that will cause damage to the airframe, however the control laws in F-22 will not allow that to happen. The 9G limit for the F-22 is imposed by the flight control computer and limits the turning performance of the aircraft at high speeds where much higher loads are aerodynamically possible.

Why not go as slow as possible, yet continue to pull 9G thus getting the highest turn rate and the smallest turn radius? Unfortunately, here too there is a catch. As your speed decreases, the wings will generate less lift and reduce the load factor that the aircraft can attain. Ultimately, you will slow down to a speed where the lift you can generate is less than the G limit. That is a very important speed. Flying below that speed means your turning performance will be aerodynamically lift limited. Flying at speeds where you are lift limited will reduce your turning ability because you will be generating less and less G as you get slower.

The lowest speed at which you can just generate your 9G limit, represents the combination of the slowest speed with the highest G and therefore gives you the highest turn rate. That speed is so important that it has a name, 'Corner Velocity' or sometimes simply 'Corner'. The Corner Velocity for every aircraft is different, but it is always the slowest speed at which you can achieve maximum load, that is the G limit, and consequently the best turn rate. Any speed faster or slower than that will reduce your turning ability, so ideally you will want to maintain a speed at corner velocity in a fight.

In order to maximise your turning performance, you need to know what corner velocity is for your aircraft, but in most cases you will be unable to sustain it. Some simulated aircraft have the power to sustain corner velocity and some do not. If you can sustain corner velocity, your problems go away. You can fly at corner velocity and maximum G for the entire fight. If on the other hand you cannot sustain corner velocity, it is of less value to you. It becomes a speed that you can only maintain for an instant as your energy bleeds down to a point that you can sustain. In that case you would be much more interested in the turn performance you can sustain. You are able to sustain a turn at all points in the envelope where the thrust exactly equals the drag, which happens at every point on the zero Ps curve. You will be able to accelerate when you have positive Ps and will decelerate when you have negative Ps. Now you are probably beginning to see how the angular manoeuvrability and energy manoeuvrability are related. Having better Ps performance, means being able to maintain a speed closer to corner velocity, which in turn translates to a higher turn rate. That is how energy and turning ability are related. We have now considered how energy can provide manoeuvrability with respect to acceleration for climbing, gaining speed, or for turning. That gives us a complete view of energy manoeuvrability.

Now that you can see exactly how energy underlies every aspect of aircraft manoeuvrability, including turn rate, roll rate, and pitch rate, we have come a long way. The next important step is to learn how to manage your energy in a way that optimises your manoeuvrability. To do that we need to be able to see the relationship between those quantities in a simple graphical, yet quantitative way. That introduces something called an Energy Manoeuvrability (EM) diagram, or 'Doghouse plots' as pilots call them.

Using Energy Manoeuvrability Diagrams

Let us take a look at our first EM diagram (Figure 12) and consider the main features. Turn rate is noted in degrees per second (DPS) along the left-hand vertical axis. Airspeed is noted in knots along the lower horizontal axis. The diagonal lines marked from 1000 feet to 6000 feet are lines of constant turn radius. The curved lines marked 2G, 4G, 6G, 8G and 10G are lines of constant load factor. The thick grey line rising to an apex is an example of the performance curve for an aircraft. Presumably these diagrams got their name because the shape of this thick line resembles the roof of a dog kennel.

The left-hand slope denotes the lift limit and the right hand slope denotes the G force limit. Because these are physical limits, imposed on one side by aerodynamic performance and on the other by the flight control system, this performance curve marks the boundaries of the flight envelope. This means that the aircraft can fly at any point on or under the curve, but at no point above it. The apex of the performance curve is therefore the maximum instantaneous turn rate possible, or corner velocity.

Look at the point marked 'B' on the diagram. At this point the aircraft has an airspeed of around 800 knots and is pulling 9G. The turn radius is over 6000 feet and the turn rate is just over 12dps. Corner velocity for this configuration is just under 350 knots. At corner, this aircraft can turn at around 28dps with a turn radius of approximately 1200 feet. You can see that it will never turn at a higher rate than that and its turn radius will never be less than 1200 feet. As speed bleeds down to around 215 knots at point 'A', this aircraft will have a turn rate of 17dps and a turn radius of 1200 feet.

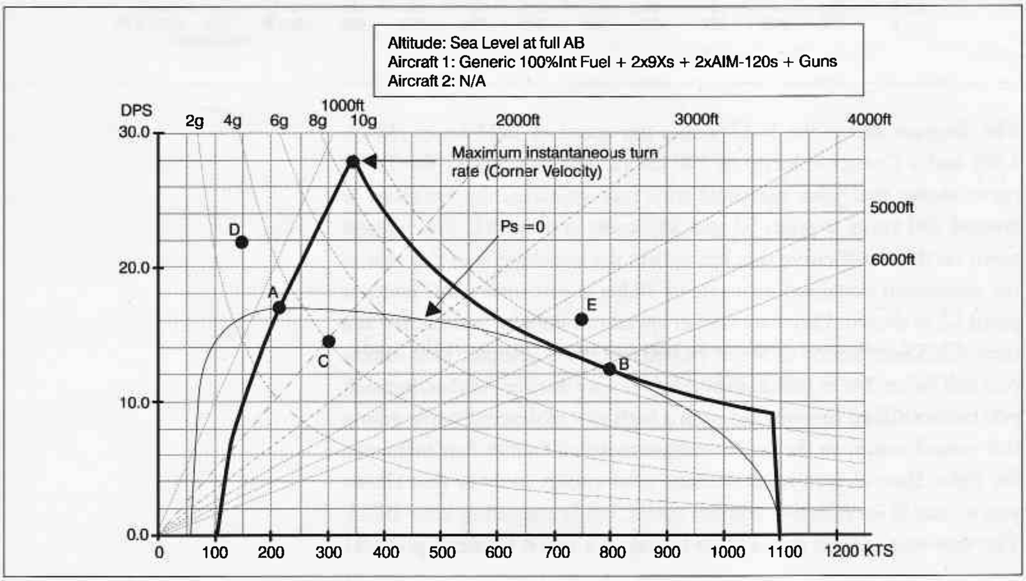
Since the performance curve indicates the upper limits of the flight envelope for this aircraft, points 'D' and 'E' are outside of the flight envelope. This aircraft can never have a turn rate of 16dps at 750 knots as indicated at point 'E' because this point is beyond the G limit. At point 'D' the aircraft is lift limited, so it ca not pull the 3G at 150 knots, that is indicated at that point. However, point 'C' is well within the flight envelope. If he chooses to do so, the pilot of this aircraft can pull the stick to 4G at 300 knots where he will have a turn rate just over

14dps and a turn radius of 2000 feet. Now let's turn our attention to another important curve.

You will notice that the curve marked Ps=0 is shown and that is a very important line. It marks the boundary between those parts of the envelope where the aircraft can accelerate or not. If you fly at any point below the Ps=0 curve you will have excess power and will be able to accelerate. If you fly at any point above the curve you will decelerate, and you will be able to sustain your speed and altitude at any point on the curve. Flying on the Ps=0 curve gives sustained turning performance. So in this example the aircraft has a sustained 9G performance only at point B. At corner speed, the envelope is way above the Ps=0 line, indeed that's as high above the Ps=0 line that you can be, so flying at the maximum instantaneous turn rate causes the largest deceleration. In this case you have a negative Ps of 800 feet/second at your corner speed. That means that if you want to sustain corner speed at 9G you will need to lose altitude by 800 feet every second. That's an extremely steep spiral dive that would be difficult to implement with any consideration to good BFM. That means you generally can't afford to try to sustain the G limit at corner speed, at least not in this configuration, the cost in altitude would be too severe. It is almost always better to trade your altitude at a less dramatic rate, combined with slightly less G for a sustained turn rate somewhere between corner and the Ps=0 curve. For example, maintaining corner, but relaxing your aft stick to 7G would give you a 22dps turn rate at a cost of less than a 300 feet/second. Easing back even further to 5.4G would drop you just onto the Ps=0 curve so you

EM Diagram

Figure 12

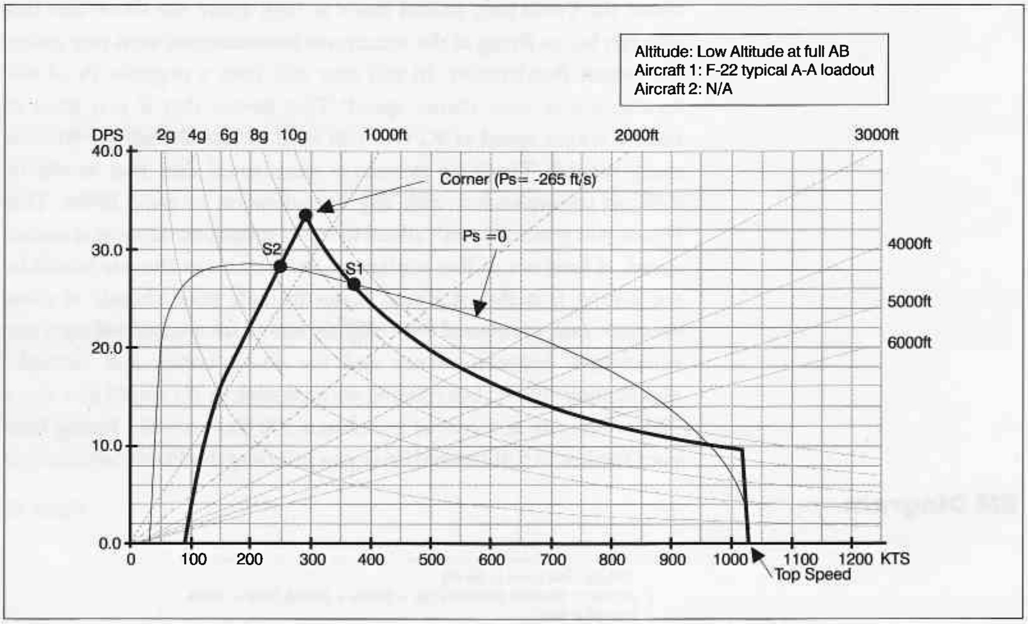


could maintain that turn at a respectable 17dps. As your aircraft burns fuel and becomes lighter the situation improves.

Energy manoeuvrability diagrams like the one in Figure 12 are sensitive to changes in weight and altitude and so it is normal to consider a whole set of diagrams that cover a range of different loading configurations and altitudes. In order to simplify this process, we will only consider a typical combat configuration for the F-22, for comparison with the other aircraft. Take a look at the F-22 EM Diagram in Figure 13.

F-22 EM Diagram

Figure 13



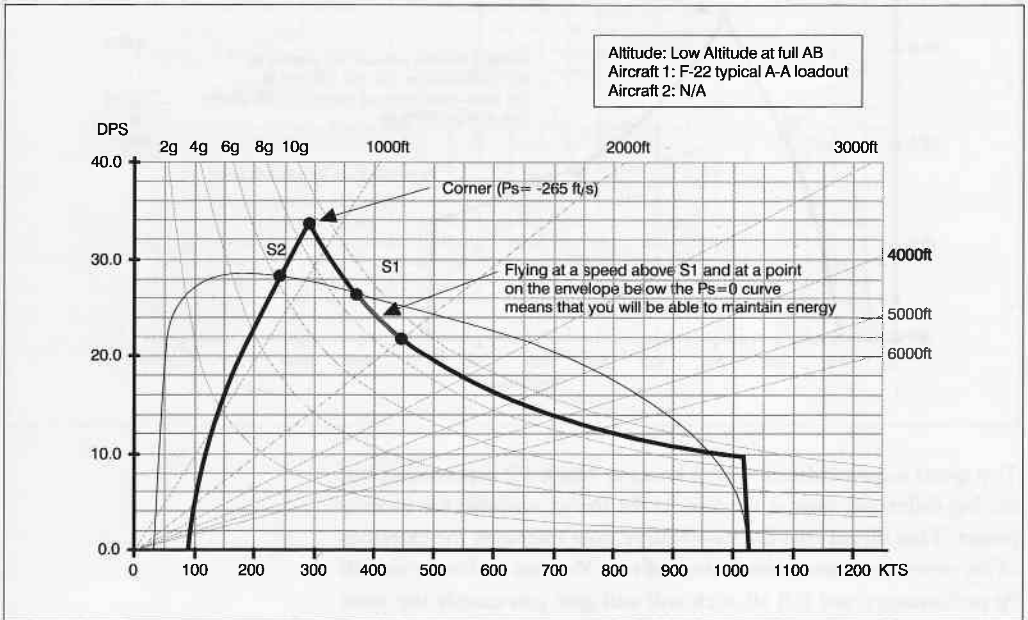
The diagram shows the F-22 with a top speed of 1033 knots (Mach 1.56) and a Corner velocity of 290 knots. The position of the Ps=0 curve shows that your sustained turn rate intersects the envelope at around 250 knots at point S2 and 380 knots at point S1. The highest point on the Ps=0 curve that lies within the envelope is in this case at the minimum sustained turn rate of 28dps at just under 250 knots at point S2 as shown. However corner speed can only be maintained at a cost of 265 feet/second or about 16,000 feet every minute. That means you will be unable to maintain corner velocity during combat, because you cannot afford to maintain such a high rate of descent while giving full consideration to the positional/geometrical factors that influence the fight. Instead, you must manage your energy in away that allows you to stay at an effective combat speed, while executing your BFM. The way you will do this will be to stay at a speed between point S1

and S2 that is between 380 knots and 250 knots respectively. That is the range of speeds you should operate within during combat, with a tendency towards the lower end of the range for slightly higher performance. However, once your speed drops below the point S1, you begin to lose energy more rapidly until you become trapped at S2. An important part of energy management is not letting that happen before it is absolutely necessary. Take a look at figure 14.

By staying at a speed just above point S1, in this case around 400 knots, will place you in the part of the envelope where you have positive Ps.

F-22 EM Diagram

Figure 14



That means you will be able to gain energy, even while pulling 9G. You can maintain energy in that part of the envelope, until you are sure that pure turn rate is needed, then you can reduce your speed by pulling slightly high in a climbing turn. As your altitude increases you will store energy and your speed will eventually fall below S1, followed by aileron rolling into a nose low turn to reduce the deceleration as you bleed through corner.

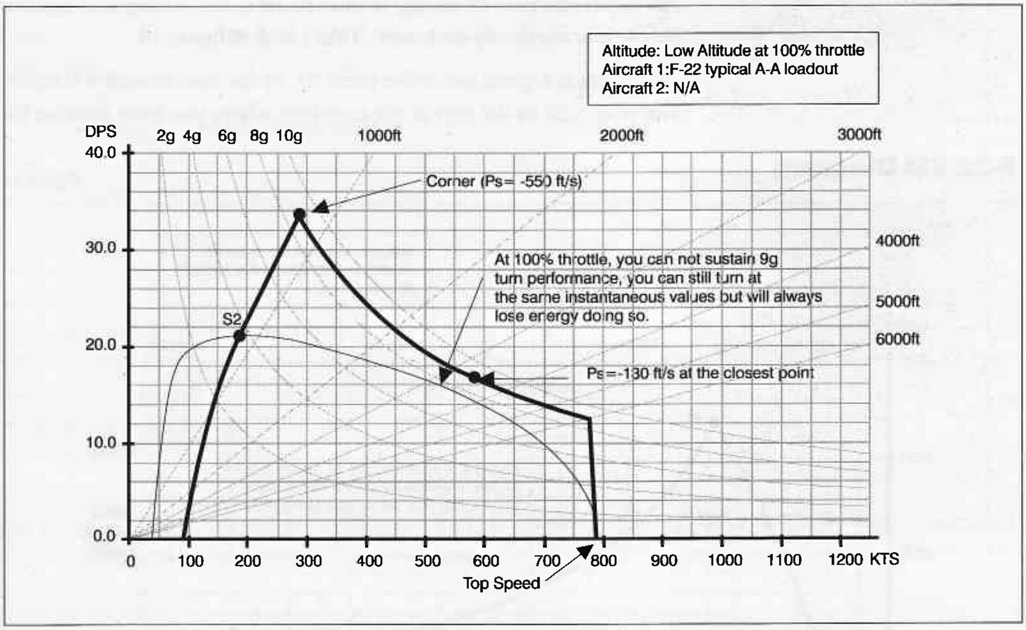
You can reduce your rate of energy loss even further by easing the stick to 8G and even 7G, never pulling harder than you need to maintain small gains on the bandit.

The diagram in Figure 14 shows your performance with fully augmented thrust, that is Afterburners (AB) on, indicated by 140 percent on the throttle. However use of the after burners consumes

your fuel at about twice the normal rate and reduces your Combat Persistence dramatically. Flying at full military power, that is the 100 percent throttle setting, gives you the performance shown on the diagram in Figure 15.

F-22 EM Diagram

Figure 15



Top speed is now reduced to 793 knots or Mach 1.2 supercruise, but the big difference now is the loss in the thrust available for turning power. That means that the Ps=0 curve only intersects the extremes of the envelope in one place instead of two. You can no longer sustain 9g performance and full aft stick will still give you exactly the same turn rates as before, but now you will bleed your speed more quickly. Also, because you now have less thrust, the point S2 now occurs at a lower speed and turn rate. Because your combat persistence or endurance is vital, you will want to know which of your adversaries can be engaged at 100 percent throttle.

You will notice that reducing the throttle from 140 percent to 100 percent had no effect on the upper limit of the envelope, but that it had a dramatic effect on the Ps curve and top speed. Consider what would happen if you were to enter an engagement with your throttle locked at 100 percent against an opponent who had full use of his afterburners. Initially you would both be able to enter the fight with equal energy, you could engage Co-E, and both begin turning with similar instantaneous rates. However, your opponent would lose energy less quickly, he would remain in the high turn rate region of the envelope for longer. He will also have a higher sustained turn rate,

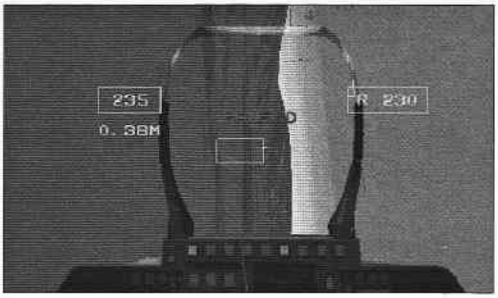


Figure 16

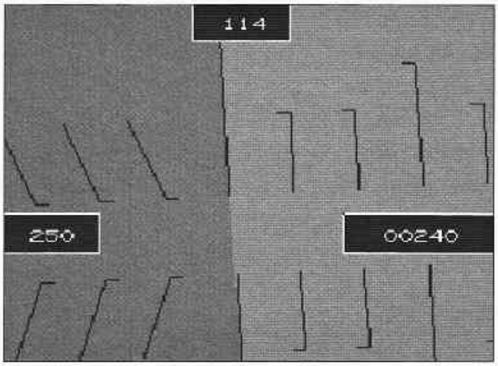


Figure 17

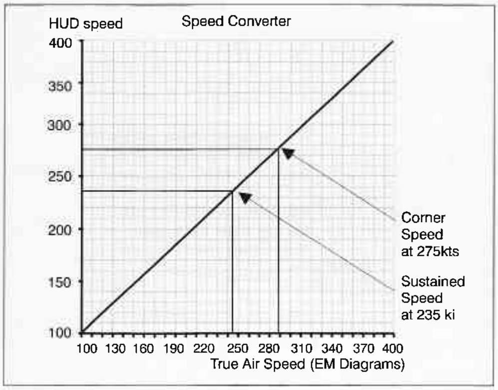


Figure 18

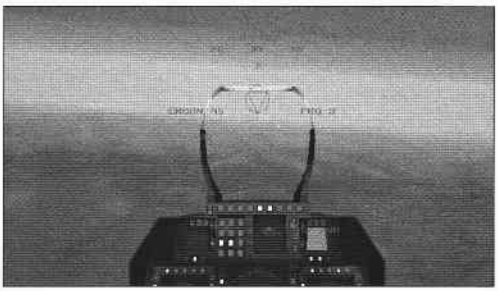


Figure 19

when he has reached his sustained turn rate it will be around 28dps while yours will be around 21. The similarity in the instantaneous curves was in this case only of temporary benefit, it was the Ps curve that could be seen to ultimately dictate the outcome of the fight. When comparing different types of aircraft, with different instantaneous and sustained values, it is important to consider both. However it will often be found that in a brief engagement, higher instantaneous performance is an advantage, while for prolonged engagements that involve tight turns and high G, the higher sustained performance is better.

Before making our first combat comparison of dissimilar aircraft, we need to pause for a moment in order to consider how we interpret the data from these curves. By that we mean, how the data from these diagrams can be related to the data available in the simulation. During a recent engagement involving a hard turning fight against a MiG-29 the following screen shots were taken.

Figure 16 show the HUD and Figure 17 the artificial horizon MFD (keypad 6) and were taken within a few seconds of each other. While the altitude varied slightly between these shots, they were taken at exactly the same speed during a hard turn. In the HUD view you see that the air speed is given as 235 knots while in the MFD it is given as 250 knots. This is because those read outs are measuring different things. The MFD reading of 250 knots is the ground speed and that is the speed used on the Energy Manoeuvrability diagrams. However the speed you will see in combat is the speed shown in the HUD, and so you need to be able to relate one to the other.

The speeds in the range 100-400 knots have been shown in Figure 18, where you will notice the HUD reading of 235 knots noted against the true airspeed of 250 knots. So for the F-22 with a corner speed of 290 knots true airspeed, you will see that relates to 274 knots in the HUD. Also the combat speed range between 25 knots and 380 knots mentioned earlier relate to HUD readings that can be read directly from the chart. So, finally we have arrived at the corner speed for the F-22 of 275 knots and a sustained speed of 235 knots.

We are now in a position to analyse our first engagement using our EM Diagrams. For our first example let us consider an engagement between our F-22 and a MiG-29. We join the fight before the merge at 20,000 feet and 2nm separation, as shown in Figure 19.

Your first thought here should be to create the lateral or vertical separation required to perform a lead turn, however that will only be possible if the MiG-29 is unaware of your presence. In this case the MiG-29 maintained an intercept course in order to cut down my turning room and force a high aspect merge. The important thing to remember at this stage is not to be tempted into a head on face shot. High aspect or high closure shots, where you are likely to fly though the debris of the explosion, are very dangerous. Parts of the enemy aircraft and pilot are going to cause severe damage to your aircraft if they hit you as you blow through. Your first objective is to cut down the enemy pilot's turning room by flying as close as you can at the merge. The merge condition is shown in Figure 20.

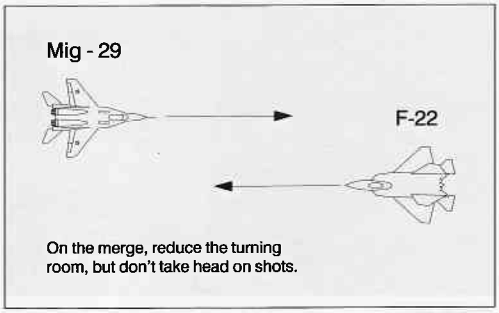


Figure 20

At this point, you have a choice between committing to a hard manoeuvring engagement, or extending. As you pass the MiG-29 your escape window is as large as it is going to get, once you begin hard turns, it will only get smaller. Having decided to commit, you need to turn into the enemy aircraft with the intention of eventually gaining a rear aspect shot. Most pilots begin their first turn, providing they have enough energy, by pulling vertically upwards into an Immelmann manoeuvre. That is exactly what happened in this fight, so let us look at that more closely.

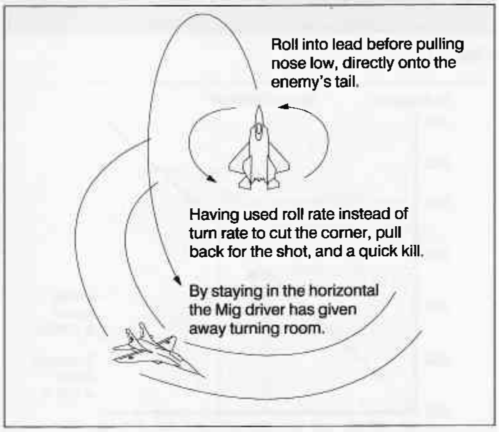


Figure 21

The Immelmann

Use of the vertical is an essential part of a flight simulation pilot's repertoire. Max Immelmann, a W.W.I ace, was the first to discover the advantage to be gained from using the vertical. That advantage occurs for two reasons. Firstly as you pull up into the vertical, it is possible to gain angles on the pilot who elects to stay in the horizontal, by using roll rate to pull into lead, before dropping your nose back down onto your opponent's tail. An almost instant victory (Figure 21).

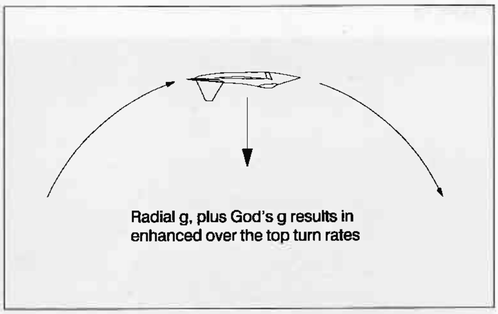


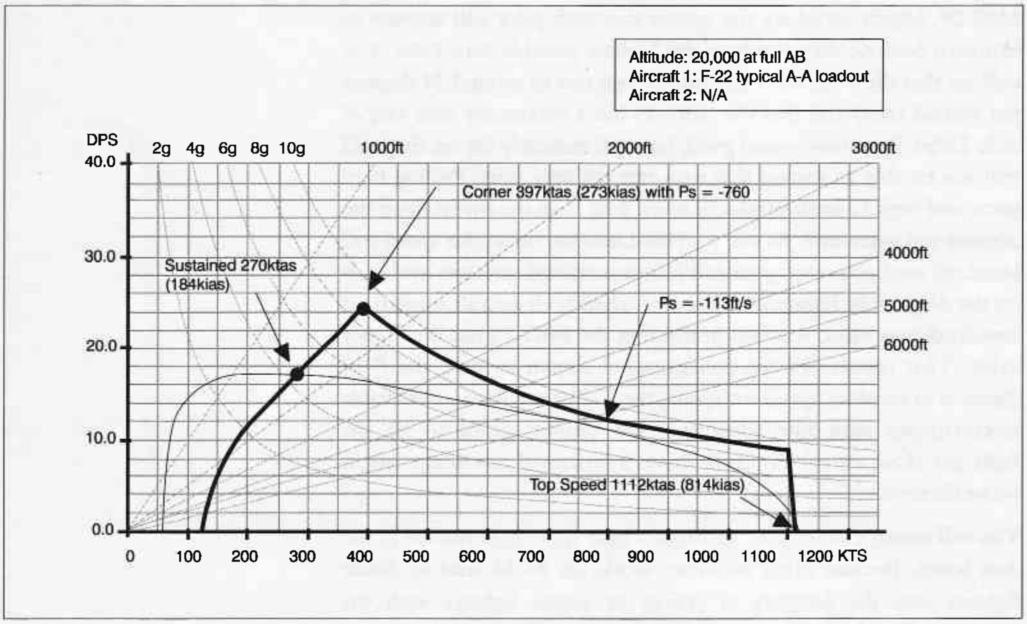
Figure 22

You will soon discover that at low speed your F-22 can execute an Immelmann and turn 180 degrees more quickly than it can in a level turn. The reason for this is that when you pull over the top, your speed drops and you gain the benefit of God's G, (Figure 22) which means that gravity adds itself to the lift from your wings and helps to tighten your turn.

Both pilots, having committed to the engagement from a neutral start, will seek to gain a position from which weapons can be successfully employed. This can only be done by intelligent manipulation of the performance and geometry involved. In this case the artificial intelligence driving the MiG-29 is far better at maintaining optimum aircraft performance than he is at analysing the geometrical situation. Because the AI will rank performance considerations more highly than geometrical ones, he can be defeated by good BFM. In order to see how this works in practice, and specifically how the fight in this example developed, let us pause to look more closely at some vital performance information on these aircraft. Firstly we will review the F-22 performance at 20,000 feet. Take a look at Figure 23.

F-22 EM Diagram

Figure 23

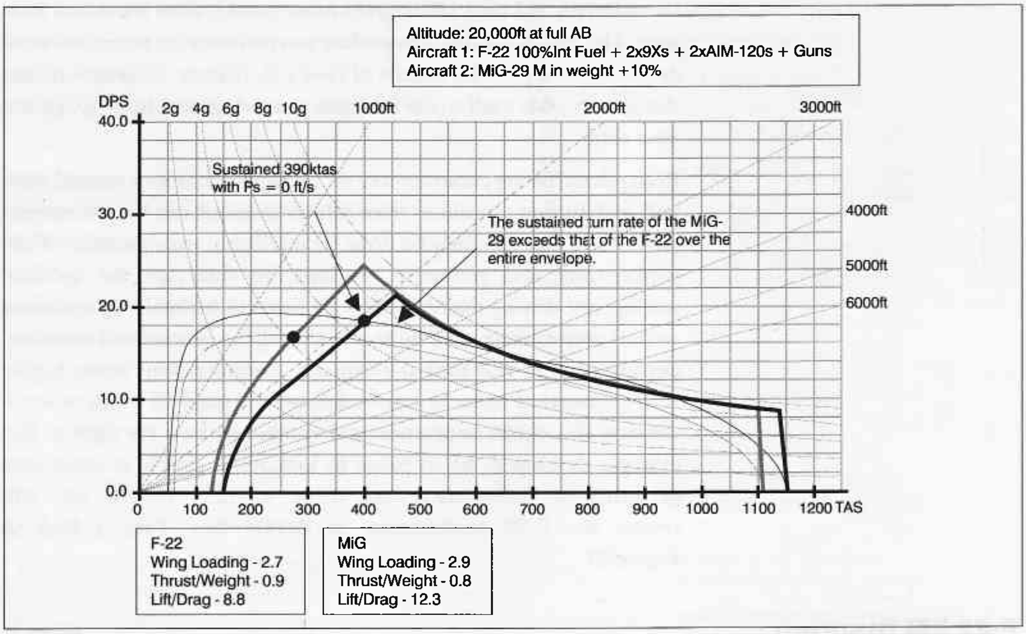


Here the main features have been highlighted. Now we can overlay onto this diagram the performance of the MiG-29 for comparison.

The first thing to notice from this overlay is that the corner speed for these aircraft is 397ktas (273kias) for the F-22 and 460ktas for the

F-22 v MiG-29 at 20,000ft

Figure 24



MiG-29. Ideally those are the speeds that each pilot will attempt to maintain because they result in the highest possible turn rates. You will see that the F-22 has a maximum turn rate of around 24 degrees per second (dps) and that the MiG-29 has a maximum turn rate of only 21dps. That may sound good, but unfortunately for us, the F-22 will not be able to sustain that turn rate for very long. Pulling hard turns and high G loads produces more drag than the thrust from the engines can overcome. As you pull hard into the turn your speed will bleed off until you reach your minimum sustained turn rate as shown on the diagram in Figure 24. However when both aircraft reach their sustained turn rates, you will notice that the MiG-29 has the higher value. That means, for the configuration shown at least, the F-22 driver is in trouble. Speed for speed, the F-22 has a very comfortable instantaneous turn rate advantage, but cannot afford to let the fight get slow, or the MiG-29 driver's sustained advantage might prove decisive.

You will notice that we have included a little more information in the data boxes. Because other reference works on ACM tend to divide fighters into the category of energy or angles fighters with the corresponding high Thrust to Weight ratio (T/W) or low wing loading, we have included those values on each diagram for the configuration given. Readers will thus be able to see how ideas already learned from those sources relate to the EM diagrams. In this example the slightly lower wing loading and slightly higher T/W ratio of the

Figure 25

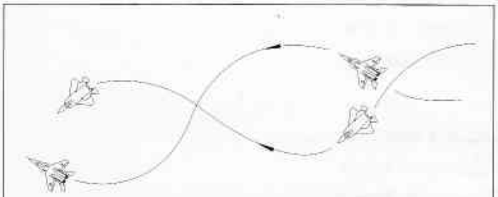

The pilot who can get slowest first will win the scissors. The traditional wisdom of staying at corner velocity does not work. Being the faster pilot with a faster turn rate will cause you to over shoot, and give a snap shot away to your enemy.

Figure 26

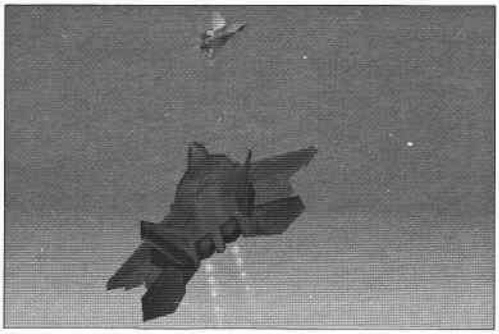


Figure 27

F-22 might appear to give it the edge, however the superior aerodynamic efficiency of the MiG-29 as shown by its Lift to Drag (L/D) ratio is the overriding factor for the configurations in this engagement. For this configuration, the combination of T/W and L/D ratios of the MiG-29 clearly give it better acceleration, higher sustained turn rates and make it the energy fighter. The lower wing loading and higher instantaneous turn rates of the F-22 make it the angles fighter. Those of you already familiar with the concepts of energy fighter versus angles fighter will now be able to apply that knowledge to engagement analysis in this and other cases. However, a study of the EM-Diagrams will make your analysis easier and quicker, while also being more quantitative. You do not just end with a hazy impression about energy-v-angles, you know exactly what part of the envelope you have an advantage or disadvantage, and by exactly how much.

Fortunately this fight developed into a nose to nose level turning engagement, as shown in Figure 25. As the two aircraft merged again, they both reversed direction in the turn, into a scissors manoeuvre. The scissors is basically a race to see which pilot can get slowest, fastest. So the F-22 found itself in a situation that called for a slow fight, against an aircraft that could out perform it in that part of the envelope. So you might assume that the F-22 driver was done for. Remember that the artificial intelligence driving the MiG-29 in this engagement is performance fixated! He knows how to sustain his turn rate, he even understands that he must slow down to avoid an overshoot, but he does not understand the geometry of BFM as well as a human pilot. Before we explain how we solved that problem, let us look at the Scissors manoeuvre in more detail.

As the aircraft in this shot passed head on, both of the pilots reversed direction, resulting in a series of turns as shown in Figure 26.

The objective of this manoeuvre is to force the bandit to overshoot. To do that you must reduce airspeed and turn radius to the point where the bandit will be forced out in front of you and into your guns' parameters. Ok, that is what you get, an overshoot and a snap shot! If the bandit overshoots enough, you can reverse early and saddle up on his tail, if not you can reverse again and repeat for another snap shot.

You might think from looking at the diagram, that the advantage to be gained is only small, after all it's hard to get a kill with a snap shot. Take another look, the important thing to notice here is that you get a shot and bandit does not, that is the sort of position you want! That is exactly what happened during this fight with the MiG-29. In Figure 27 you can see that the MiG-29 has overshot by a considerable margin and he is reversing in front of our guns. Not a smart move!

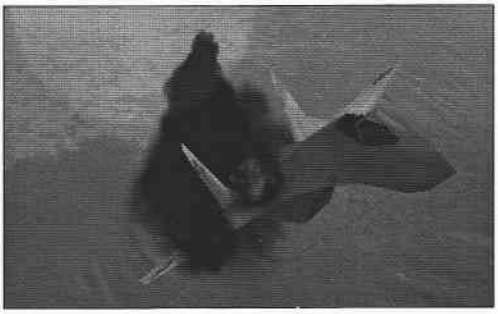


Figure 28

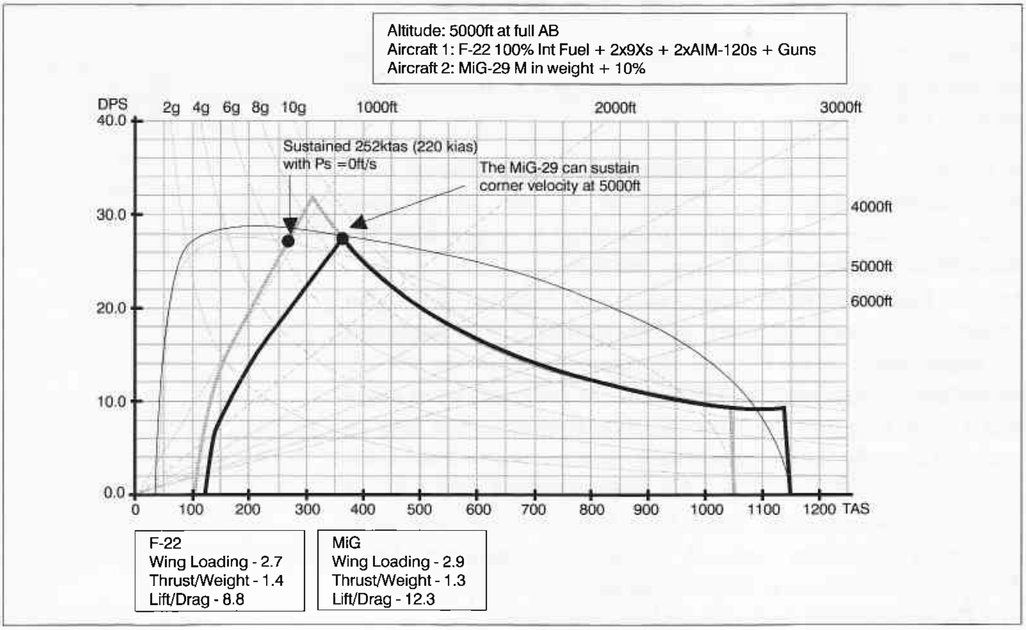
The MiG-29 driver failed to appreciate the implications of the geometrical situation he was being forced into. Consequently, his blind adherence to a maximum rate turn, was his demise. A few moments later a short burst of cannon and the MiG took damage (Figure 28).

However a snap shot may leave your opponent smoking, but still very dangerous. Before we explain how the final blow was delivered let us take a step backwards. You will recall that the MiG-29 actually had a performance advantage at 20,000 feet. How did we solve that problem? As you may have suspected, the scissors was the solution. If this fight had developed into a nose to tail turn, we would have been in serious trouble, the MiG-29's better aerodynamic efficiency and thus sustained turn rate advantage, would have eventually caught up with us. Had we tried to pull hard turns with the MiG-29 driver, the fight would have developed into a Lufbery. The Lufbery is named after Raoul Lufbery the American WWI ace that first used it. Let us take a moment to see how that would have worked out.

The Lufbery is simply a turn that spirals downwards. When you get into a turning fight with a bandit, you normally want to turn as rapidly as possible. That means you need to turn at corner velocity. You will notice the corner velocity for both aircraft indicated on the EM diagram Figure 29. The problem is that even with full Afterburners (AB) you just will not be able to maintain that speed. In a level turn you will bleed down to your sustained turn rate. If you want to sustain a higher turn rate you will need to trade altitude for airspeed. So if you drop your nose below the horizon you will be able to maintain a higher speed. That means a higher turn rate. You are converting some of your potential energy into kinetic energy. Your turn rate improves rapidly with speed, because the EM diagram curve is very steep below corner velocity, every extra few knots are worth a big increase in turning ability. That is why going into a shallow dive is worthwhile. The disadvantage is that you do lose altitude rather quickly, and will soon find yourself on the deck, low and slow with nowhere to go! Things are even worse than that in this engagement, because the diagram shows that the MiG-29 driver will be able to maintain corner speed for less

F-22 v MiG-29 at 5000ft

Figure 29



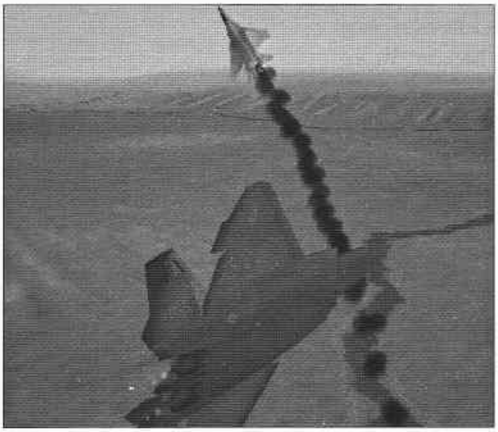


Figure 30

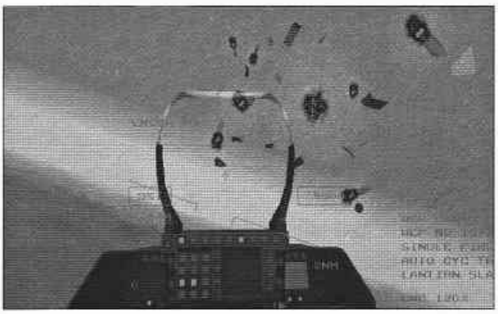


Figure 31

cost in altitude, because his Ps=0 line is higher. That means had we elected to use a Lufbery we would have run out of energy first! The F-22 would have reached the deck, and with no more altitude to trade, its speed and turn rate would have dropped dramatically. The higher MiG-29 driver would have been able to convert his energy to position and would have had a kill very soon afterwards.

However in the scissors manoeuvre, you just want to get slow first, a higher speed and a higher turn rate just leads to an overshoot. If you take a look at the EM diagram for 5000 feet in Figure 29 you will see what we mean.

At this altitude the MiG-29 driver can sustain corner speed, and that is just what Artificially Intelligent MiG drivers will do if they can. The MiG in this case attempted to maintain corner at 365 knots some 100 knots faster than the F-22's sustained turn. The Artificially Intelligent MiG was fixated on performance and maintained corner velocity at the expense of the proper geometrical considerations of the BFM involved. In Figure 30 you will see that the F-22 has saddled up for the duration, the MiG driver appears to realise his

mistake too late and tries to initiate a rolling scissors in order to lose some of the speed that got him into difficulty in the first place.

The MiG-29 in this fight never actually lasted much longer, his attempt to get higher and slower by executing a high G barrel roll ended as Figure 31 shows.

At this new lower altitude, you will notice that the performance ratios have changed slightly. The F-22 still has the lower and therefore better wing loading, and a slightly better thrust to weight ratio. The MiG-29 has a higher lift to drag ratio and that indicates that the MiG has the higher sustained values, while the F-22 has the higher instantaneous values. Application of those tactics normally assigned to the angles fighter for the F-22 and the energy fighter for the MiG-29 would have been appropriate. The MiG-29 in this example lost a fight that it might have won had it not chosen to fight the sort of fight we wanted. Generally, the outcome of a fight between the F-22 and MiG-29 is less clear. The MiG has the better sustained turn rate and acceleration which could easily have lead to victory had more appropriate tactics been employed. The tactics used against the MiG-29 exploited differences in the envelope that were apparent from the EM-Diagram overlays used to analyse the engagement.

The MiG-29 in this example is by no means the most deadly adversary you will encounter in the simulation. Some behave more appropriately and even slow down in the scissors manoeuvre when required to do so. Each aircraft has its own strengths and weaknesses that can be exploited with the benefit of EM-Diagram overlays and so many more examples will be explored in Chapter 10, 'The Enemy'.

Thrust Vectoring

When we talk about a quantity that needs to be defined both by its size and by its direction it is referred to as a vector quantity. A vector is simply the name given to anything that can be expressed in both magnitude and direction. So for example a velocity of 500 knots heading due north, is called a velocity vector because it has a magnitude of 500 knots and a direction of 360 degrees. Thrust is also a vector quantity, because it has a magnitude and a direction. In the case of the F-22's F119 engines that means 35,000lbs of thrust each, acting along its axis. Normally the thrust of an engine is fixed along its axis, but on the F-22 the nozzles can deflect the thrust by 20 degrees upwards or downwards. The direction of the thrust can therefore be changed, thus changing the thrust vector, and such a variation when applied, is simply known as thrust vectoring. The advantages of thrust vectoring can be listed as follows:

1. Enhanced control in flight conditions where conventional aerodynamic controls are less effective.
2. Enhanced cruise performance.
3. Reduced take off distances.
4. Enhanced manoeuvrability.

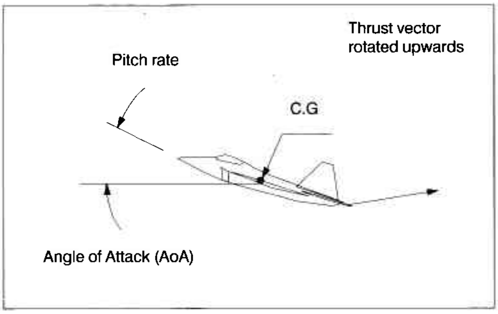


Figure 32

The first of these benefits is due to additional control power available in the form of the directed thrust, the second due to reduced trim drag, the third due to lower rotation speeds and lastly, and most interestingly in this chapter, the enhanced manoeuvrability. Let us examine that in more detail.

Firstly, consider what happens when the thrust vector nozzles are deflected upwards. As the nozzles rotate, the thrust creates a nose up pitching moment about the Centre of Gravity (C.G) of the aircraft. The effect is as if some one had placed a spanner on the centre of the aircraft and applied a torque that rotated its nose upwards. The upward movement of the nose of the aircraft due to the rotation about its centre of gravity is called pitch, the rate at which it occurs, is known as the pitch rate. This should not be confused with turn rate, which refers to the motion of the aircraft as a whole around its turn circle. Figure 32 is a simplified illustration of the effect.

As the nozzles rotate and cause the nose to pitch up, the thrust pushing the aircraft forward is reduced and the lift and drag are increased causing an increase in the G load and deceleration. As the angle of attack increases to the post stall regime, the lift decreases reducing the G load and drag once again. The main effect of this action is the rapid upward nose movement and rapid horizontal deceleration of the aircraft. There are advantages and disadvantages in producing these two effects simultaneously that will now be discussed.

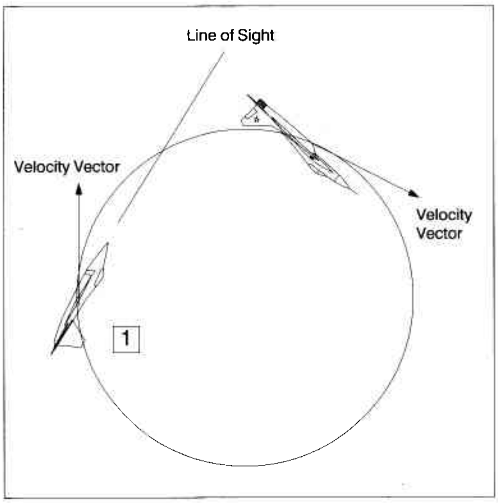


Figure 33

Thrust vectoring can be used to point the nose of your aircraft, and thus your weapons at an enemy, in the hope of tracking long enough to deploy them. If successful, as well as a kill, you will have ended the fight quickly thereby reducing your vulnerability to other distant hostile aircraft. However the energy loss associated with this action, will dramatically increase your vulnerability to less distant threats, particularly those within weapons range. Generally any prolonged use of thrust vectoring to point the nose of your aircraft at the enemy, will bleed off considerable energy. Therefore the rapid pitch rate will be accompanied

by a reduction in speed and turn rate and general loss of manoeuvrability. This makes it a one off opportunity that if unsuccessful will result in extreme low energy and high vulnerability.

Alternatively, you can choose not to deploy the thrust vectoring nozzles, and remain inside the conventional flight envelope. That allows you to maintain the highest combination of positive Ps and high turn rate. Staying inside the conventional envelope may protract the engagement leading to higher risk from distant enemy aircraft, however this will ensure the highest energy state possible, which in turn will maintain the largest possible escape window and defensive and offensive options.

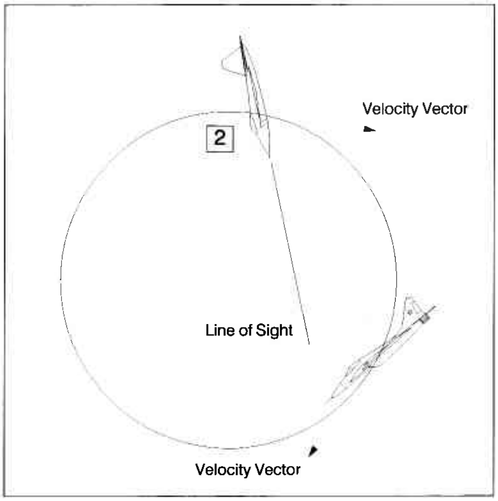


Figure 34

Let us look at an example. In Figure 33 you see an F-22 driver at time 1, who needs to make considerable gains before achieving weapons parameters. The turn circle has been drawn smaller in proportion to the aircraft for clarity so bear in mind that the ranges involved here are more than they appear. The situation is clearly one of advantage for the F-22, but there is still every likelihood that this will be a protracted engagement. Should the urgency of the situation, perhaps due to the approach of other bandits or low fuel, compel this F-22 pilot to attempt to end the fight quickly, he can point his nose across the circle as shown at time 2 in Figure 34.

Here you see that the F-22 pilot has been able to rotate his aircraft about its centre of gravity by changing the direction of the exhaust nozzles. This has led to a rapid, albeit brief, change in the line of sight. This will possibly allow a missile lock and launch depending on such factors as how long the nose can be held within parameters, the range and aspect and so on.

The nose pointing ability will be accompanied by rapid loss of energy caused by the extra drag. Should the weapon deployment be successful, the energy could be recovered during the pilot's egress. However the energy loss makes this a very risky option, because in the case of unsuccessful weapon employment, you will have handed a big energy advantage to your adversary. For example, a speed loss from say 300 knots to 200 knots will be accompanied by a reduction in your turn rate of over 10dps resulting in one very happy MiG driver.

The reader will need to weigh the option of spending every drop of energy for a snap shot, against remaining inside the conventional envelope as individual circumstances dictate. However, if survival is your main concern, do not do anything to reduce your Es more than necessary.

Part II Missiles

Missile Performance

The methods used to defeat enemy missiles can be broken into two categories, those that involve manoeuvres, and those that depend upon counter measures. The use of evasive manoeuvres to defeat an enemy missile is the first option available to you and begins beyond the range of the enemy detection system. Manoeuvring your aircraft to maintain the range and aspect required to remain outside enemy launch parameters is the only certain way to defeat enemy missiles. Preventing the launch is the first and best option. In situations when this is not possible you will need to manoeuvre in a way that maximises the potential miss distance for a missile homing on your aircraft. Due to the combination of very high speed, high load factors and the pursuit course flown by the missiles in F-22, it is not always possible to generate suitable miss distances by manoeuvring alone (Figure 35). However it is possible to manoeuvre in a way that enhances the effect of counter measures.

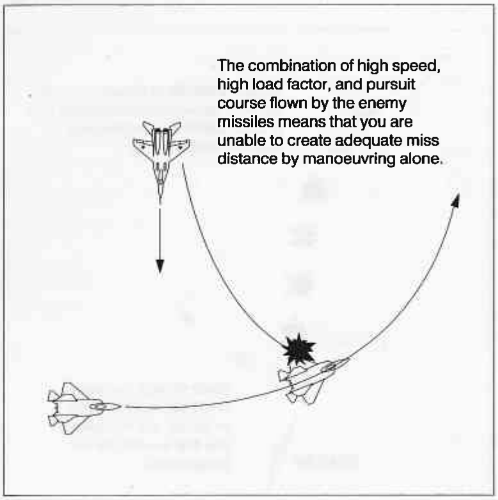


Figure 35

Counter measures involve the use of electronic noise jamming and expendables such as chaff, flares or decoys to deceive the seeker of a tracking missile. They are intended to either mask the existing signature, by drowning the echo with smart noise as in the case of Electronic Counter Measures (ECM). Also to provide multiple radar or heat sources, in the hope that one will be mistaken for the target return and thus cause the seeker and guidance system to lock and home onto the counter measure. When a missile is prevented from tracking due to electronic jamming or deceived into homing towards a false return in this way, it is said to have been spoofed. So, once a missile has been launched you need to use a combination of manoeuvring and counter measures in order to maximise the probability that a missile will be spoofed and thus optimise your survivability. This can be done by taking advantage of the characteristics of missile, chaff and flare performance (Figure 36).

Firstly missile closure should be minimised by flying directly away from the missile and flying as low as possible. Most Air-to-Air missiles use rocket propulsion either exclusively or at some stage of their flight, and the thrust from such motors decrease at lower altitude, where the drag increases. So for example, missile range at sea level is approximately half that at 20,000 feet, so that altitude reduction will result in significant degradation in the missile's range. Reducing your altitude can also reduce the effectiveness of the missile by forcing a look down shot and increasing ground clutter and possible terrain masking. Diving to lower altitude during manoeuvring will also help increase your speed. The combination of high speed and flying away from the missile will help to reduce closure. That will increase the time of flight for the missile, thereby creating more time for the deployment of a larger number of expendable counter measures, thus increasing the probability that one will deflect the missile. However, chaff, flares and decoys have a very short life span and if they expire while your aircraft remains within the limits of the missile's seeker head, there is a very good chance that it will re-acquire your aircraft. For that reason flying directly away from the missile is not a wise option. The optimum heading involves keeping the missile at around 30 to 40 degrees aspect, to maximise the time of flight and thus maximise expendables deployment, while providing just enough flight path misalignment to prevent a spoofed missile easily re-acquiring your aircraft (Figure 37).

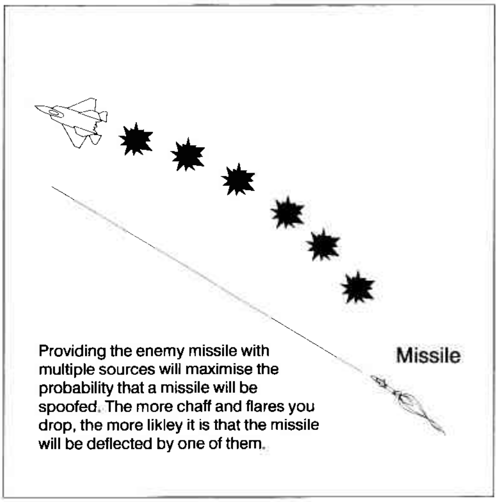


Figure 36

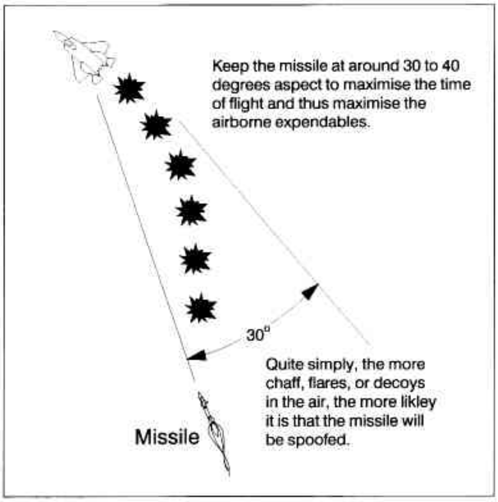


Figure 37

Quite simply, the more chaff, flares or decoys in the air, the more likely it is that the missile will be spoofed. The purpose of manoeuvring is then three fold, firstly to maximise the time of flight by diving for speed to lower altitude in a direction that minimises closure. Secondly to create enough aspect to force a spoofed missile to manoeuvre away from your aircraft, thereby preventing it from re-acquiring you when the flare or chaff expires. Thirdly, once you become aware that a missile is no longer tracking your aircraft (by observation of the changing line of sight rate) you must pull a last ditch manoeuvre that will maximise the miss distance and get your aircraft outside the viewing cone of the missile's seeker head as quickly as possible.

In practice the procedure is carried out as follows (see Figure 38):

1 As soon as you hear the launch warning, check the threat MFD to ascertain the number and location of missiles, and so that you avoid any disorientation that might prove fatal in the following seconds.

2 Go to the missile padlock view and execute a diving turn that places the missile over your shoulder at 4 or 8 O'clock (30 - 40 aspect). Once the turn is complete maintain the dive, you will get faster while taking the missile low. The missile will however gain speed initially because of the conversion of its potential energy to kinetic energy. However, forced to manoeuvre at low altitude, with the least thrust and greatest drag that advantage will soon dissipate. As soon as you gain visual tally on the missile, begin launching expendables.

3 Watch the missile position on the canopy. If the missile maintains a fixed position, that is, it does not appear to be moving backwards or forwards on the canopy; it has a zero line of sight rate. That means the missile is tracking your aircraft. Continue to deploy expendables at the maximum rate possible and concentrate hard on the position of the missile in the padlock view. You will only have a fraction of a second to notice the change in the line of sight rate of the missile, which will indicate a spoof.

4 Should you see the missile begin to move backwards on the canopy, that means that the missile has been distracted by your expendables, it has been spoofed. The instant you notice the change in the line of sight rate, execute your last ditch manoeuvre by turning hard into the missile, driving for a beam aspect to escape the viewing cone of the missile.

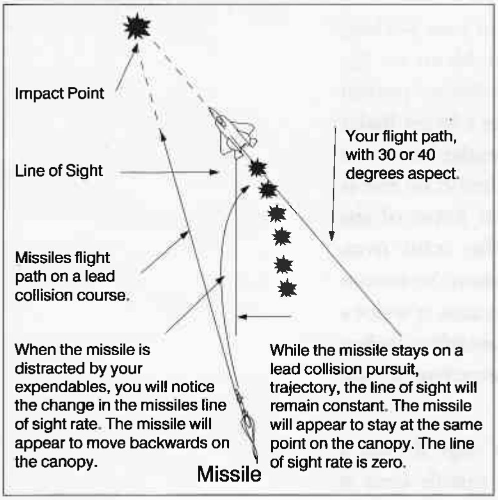


Figure 38

Stage three is critical because it is essential to distract the missile with your expendable ordinance in order for a successful evasion to occur. Quite simply, the more expendables you can get into the air in the last few seconds the better the odds are for a successful avoidance. Stage four should not require the use of thrust vectoring because that will actually reduce the line of sight rate, rather than increase it. Thrust vectoring will, by creating pitch rate, spoil your observation and correct interpretation of the line of sight rate. Observation of the line of sight rate is so vital to successful missile avoidance, you should do nothing that might distract you from that.

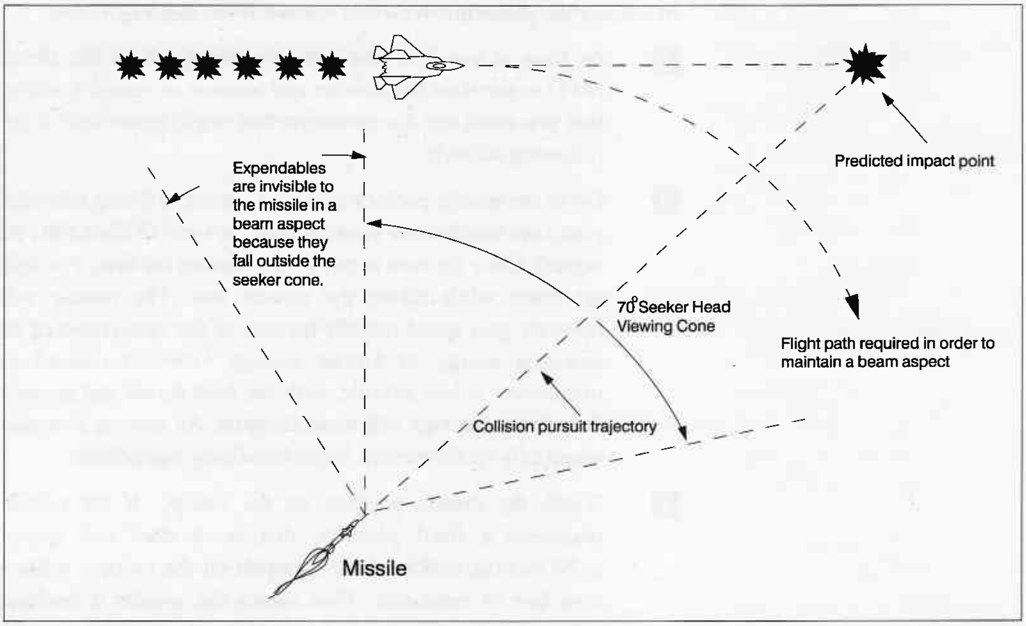


Figure 39

In stage four we advise beaming the missile during your endgame manoeuvre, let us examine that more closely. Beaming is double edged and can be a good or bad thing depending on several factors. Beaming will only degrade those systems that depend on Doppler radar or infrared reflections for guidance. Should the missile be able to maintain the lock regardless of the beam aspect, the beam aspect will have only resulted in a less than optimum heading. It will have increased missile closure, reduced deployment of expendables and in the case of missiles using a lead collision pursuit trajectory, fewer expendables inside the limits of the seeker cone (Figure 39).

When the missile is in the forward quarter, or in front of your 3-9 line, beaming does nothing to increase line of sight rate problems for the missile. This is especially true due to the lead collision pursuit trajectory flown by the missiles in F-22. It also exposes a larger Radar Cross Section (RCS) to the seeker and will place expendables farther from the missile than your aircraft. That will reduce their echo and as the range closes may place them beyond the gimbal limits of the missile seeker head. That will further reduce the echo from expendables making your aircraft the dominant reflection. So to sum up, in the above situation beaming does not work, because it is not a good way to reduce closure. It simply means that you are releasing less expendables, that due to their position, are less attractive to the missile anyway.

However, if you fly the evasive vector described in stage 2 until a missile has been distracted, and then turn into the missile once it moves behind your 3-9 line, beaming will be much more effective. In

that situation beaming will get you outside of the missile's viewing cone quickly, while providing the missile with the best view of your expendables. Due to the new missile trajectory expendables will now be closer to the missile than you are. As you turn to the beam, your expendables will also present a beam aspect that will temporarily have the same relative speed as your aircraft, and will thus be more attractive to Doppler radar seekers.

The conclusion is that missile avoidance should be attempted in two phases. The first phase consists of an attempt to minimise missile closure, and thus maximise the probability of a successful spoof, as described in stages 1 and 2. Outrunning the missile is better of course, but unlikely for some of the enemy radar guided missiles in F-22. The second phase then involves a last ditch manoeuvre. That has been described in stages 3 and 4 as the presentation of a beam aspect to the missile, but is only advantageous once you notice a change in the line of sight rate. Beaming too early, or beaming a missile that is still tracking you, is counter productive!

Lastly then, in the case of a missile using infrared homing, a slightly different approach is required. These missiles are short range, and generally launched from well within Rmax. In this case, the evasive strategy needs modification. The time of flight for these missiles is very much less than for the longer range missiles and so the first phase needs to be omitted and the second phase begun the instant you are

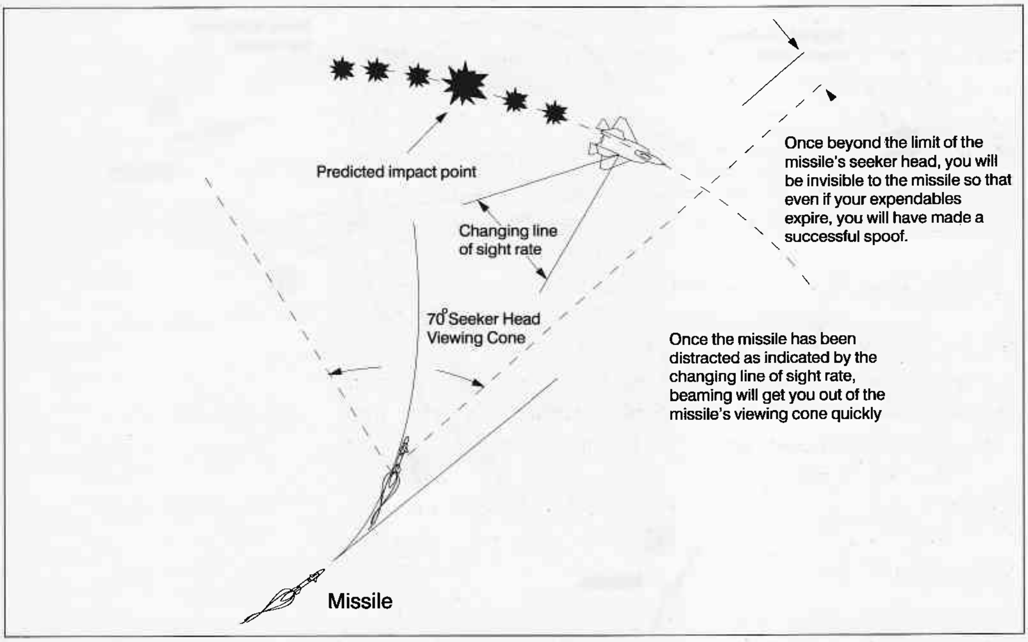


Figure 40

aware of the launch. However in the second phase of the evasion, a beam aspect is no longer the optimum orientation. You must now turn into the missile, past the beam, for the highest aspect possible. This will reduce the thermal signature and the Probability of Kill (PK) for the approaching missile. If you have time to pull the missile in front of your 3-9 line, you should begin a barrel roll around the missile, in order to maintain the high aspect while avoiding flying directly into the missile.

After reading this chapter you will have at your disposal information that might have otherwise taken many months of dedicated flying to ascertain. Now you will be able to fly every engagement in a way that will make best use of your aircraft's strengths while taking advantage of your opponent's weaknesses. You will be able to fly your BFM confident in the knowledge that you are not only out manoeuvring your opponent, but that you are also out turning him. This combination will make you an extremely formidable adversary. But most of all we hope that this information has shortened the learning process and provided you with an accelerated route from novice to ace.

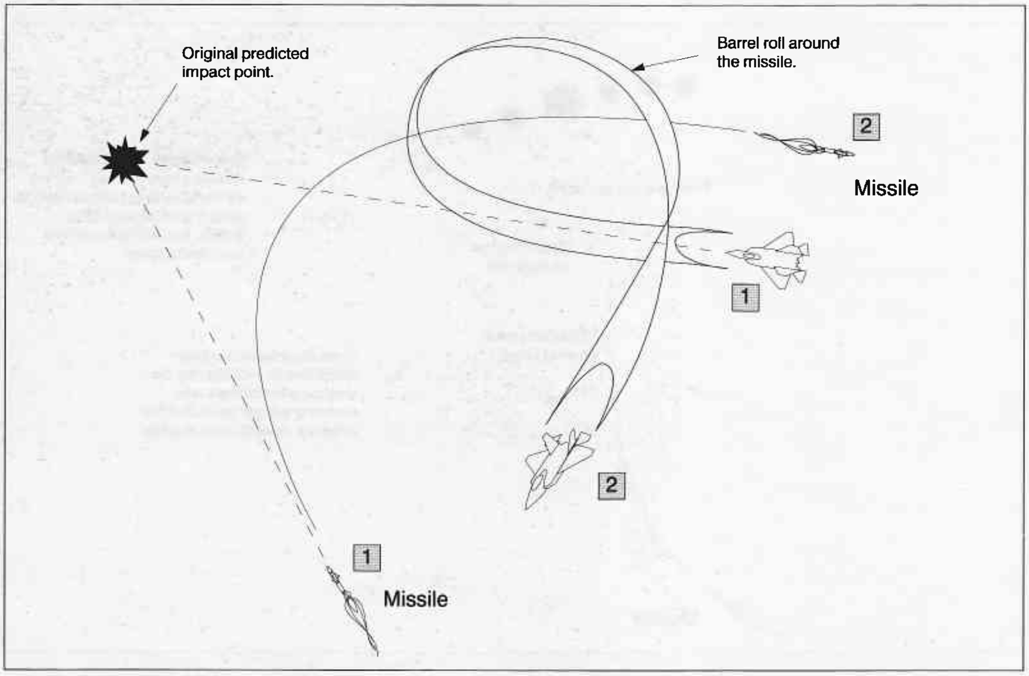
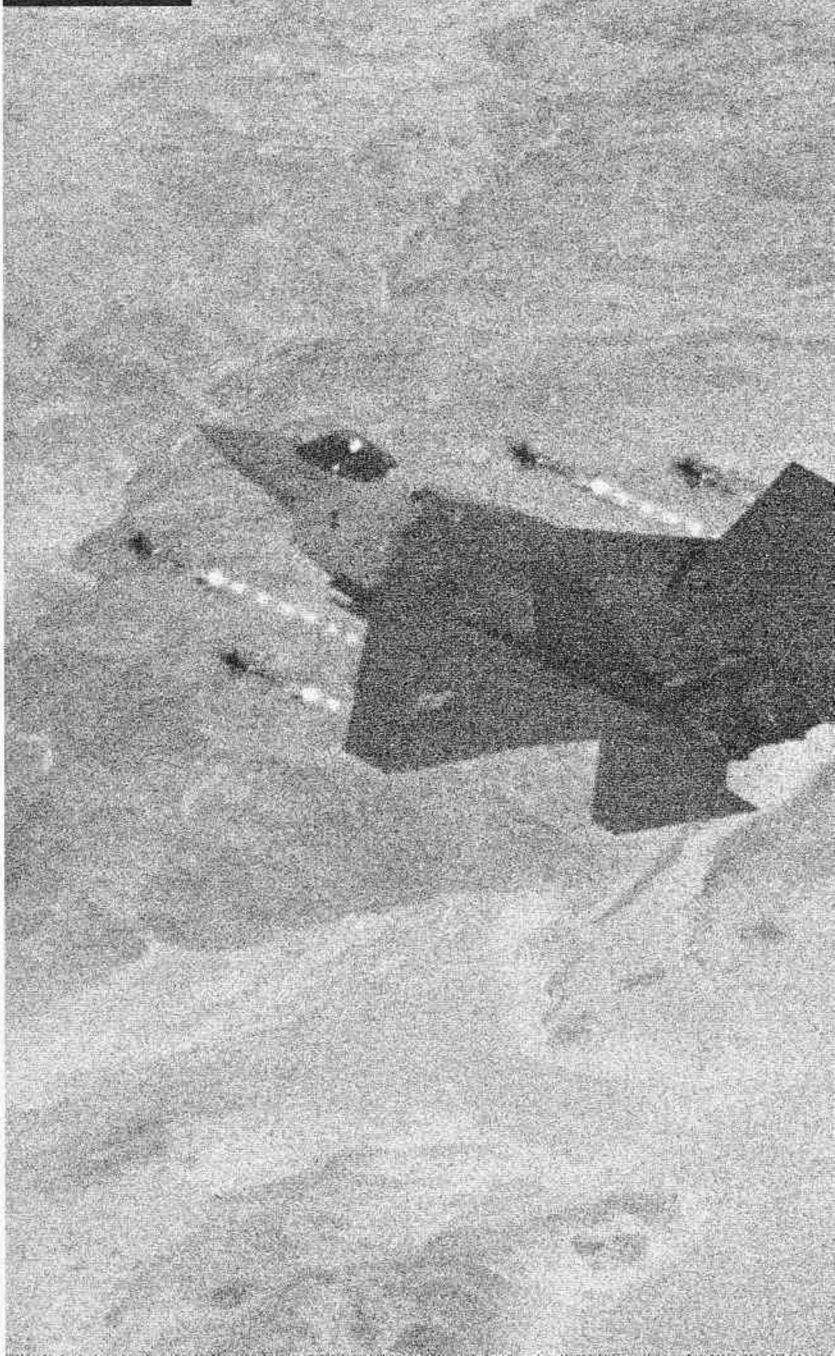
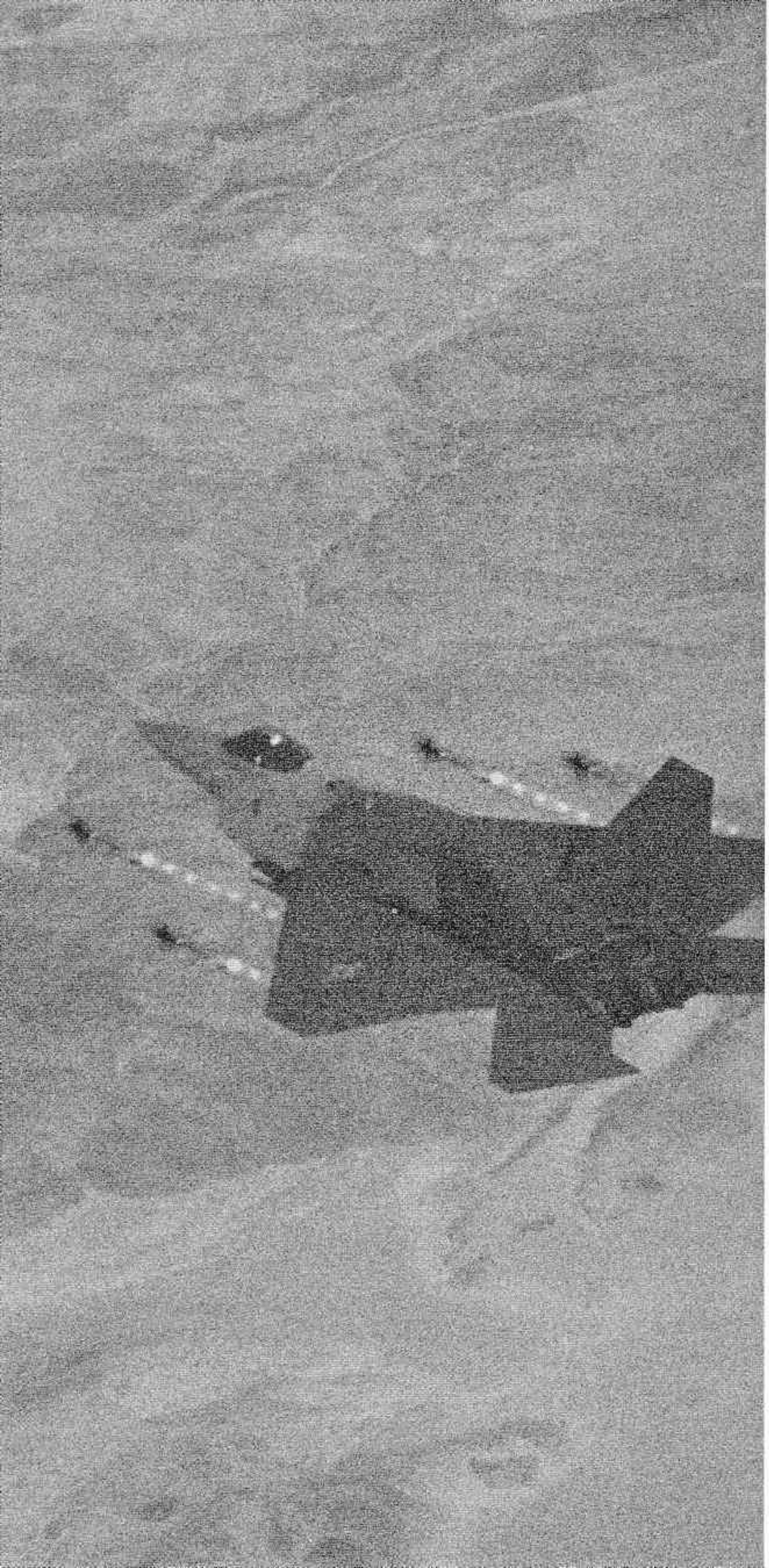


Figure 41

Chapter 5



A2A Weapons



CHAPTER 5

Chapter 5

A2A Weapons

Air-to-Air (A2A) weapons can be grouped into three categories, roughly corresponding to three types of engagements. Long and medium range, radar guided missiles are intended to strike at targets 'Beyond Visual Range' (BVR). Short range, infrared (IR) guided missiles are useful against targets from just inside visual range, down to one mile or so. Finally, cannons are for those times when you want to get up close and personal, effective only at ranges of about one mile or less.

Of the three types of engagements, eliminating an enemy threat from BVR is the most desirable. This exposes your aircraft to the least amount of danger and affords the greatest probability of being able to continue towards your assigned target. If an enemy succeeds in defeating long range missiles, or appears suddenly within visual range, successfully scoring a kill with short-range missiles allows you to quickly end the fight. If missiles are unavailable, you will have to bring all of your dogfighting skills to bear in order to shoot down the enemy with your cannons quickly and efficiently.

While engaging an enemy aircraft at close quarters with guns may be glamorous, guns should almost never be your weapon of first choice when it comes to eliminating an airborne threat. Even for the most skilled aerial marksman, a guns kill takes time to set up and execute. The longer an engagement lasts, the more likely it is that you will make a mistake - a fatal mistake. In addition, a protracted engagement allows the enemy time to vector additional resources to the area, increasing the risk to your aircraft and your mission. Finally, combine these factors with the fact that dogfighting uses up precious fuel resources very quickly, and you have a recipe for mission disaster.

The F-22 is designed to employ stealth tactics, allowing you to enter the fight on your terms, not the enemy's. You will often be tasked with high value targets. Avoiding engagements along the way is to your advantage. However, the enemy is rarely so cooperative as to allow you to strike unmolested. The purpose of this chapter, therefore, is to prepare you for those moments when an engagement is inevitable. Proper use of your A2A weapons can mean the difference between mission success and failure.

A Brief Introduction to Missile Propulsion, Guidance, Fusing and Warheads

The majority of A2A missiles employ solid fuel rocket motors. This enables them to achieve very high thrust-to-weight ratios and a high degree of launch reliability, while keeping size to a minimum. Having small, lightweight weapons mean that you can carry more of them, giving your aircraft a deadlier punch. Rocket motors generate rapid acceleration and high terminal velocities, translating into extremely agile and deadly weapons. Long range missiles will often use other propulsion systems, such as ramjets, to extend their effective range as much as possible.

As modeled in F-22 ADF, three different A2A missiles are available to you. Two variants of the AIM-120 AMRAAM (Advanced Medium Range Air-to-Air Missile) cover long and medium range engagements. The AIM-120R is a ramjet-powered missile, capable of hitting targets at ranges in excess of 40 nautical miles. The AIM-120C is a medium range, rocket-powered missile with a range of about 30 nautical miles. Finally, the AIM-9X Sidewinder missile is a short range, highly manoeuvrable rocket powered missile, effective on targets at ranges of 10 nautical miles or less.

Guidance systems come in three varieties: active, semi-active and passive. Active and semi-active guidance systems typically rely on radar for targeting and tracking and are found on medium to long range missiles. Doppler radar is commonly used to detect the motion of the target aircraft and reject very slow targets or stationary terrain features. Passive systems usually lock on to the heat generated by the target's engines and leading edge surfaces and are found on short-range missiles.

Both active and semi-active missiles take their initial guidance cues from the launching aircraft. Once launched, actively guided missiles are able to rely on their own internal radar systems. Semi-active missiles rely on radar returns generated by the firing aircraft and require that the launching aircraft maintain a radar lock throughout the intercept.

Passive, IR guided missiles, can either take initial guidance cues from the launching aircraft or independently seek out heat sources prior to launch. Once a target is acquired and the missile is fired, these weapons will pursue their quarry with no further input from the launching aircraft

The AIM-120 missiles used in F-22 ADF/TAW are fully active, allowing them to be used as 'fire and forget' weapons. They do not rely on, or require the firing aircraft to maintain a lock on the desired target

until impact. To improve its accuracy, the AIM-120 is capable of receiving updated target information from the F-22 while in flight. It does not require updates to locate, identify and pursue its target, but it will exploit them if available.

Once the missile reaches its target, the fusing mechanism detonates the missile warhead in order to achieve a kill. Fusing mechanisms come in various forms, however proximity fuses are most commonly found in A2A missiles. Like tracking systems, these fuses rely on either actively generated signals or passively detected emissions from the target aircraft to determine the optimum moment of detonation.

Fusing mechanisms are designed to match the intercept conditions that the missile will likely encounter and are designed to detonate the warhead at or near the point of greatest potential damage to the target. As a result, the effectiveness of a particular weapon system may be degraded if the proper conditions are not met at the time of intercept. For example, missiles designed for a low closure rate may detonate too late if fired at a target approaching head on. Because of their sophisticated, active fusing mechanisms, the missiles modeled in F-22 ADF will adapt to any intercept conditions, ensuring proper detonation timing.

Finally, design of the warhead plays a critical role in how effective the missile will be once it reaches its target. The AIM-9X and AIM-120 missiles modeled in F-22 utilise 'fragmentation' warheads which scatter deadly shrapnel across a relatively large area. This enables the missiles to achieve a kill without the need to strike the target directly. It takes only one piece of shrapnel, sucked into an engine inlet, to destroy the delicately balanced turbines and fatally cripple an enemy aircraft.

Maximising the Probability of Kill (PK)

A number of factors affect the probability that a missile, once locked on to and fired at a target, will achieve a kill. These include the speed and altitude of both the launching and target aircraft, as well as the range to the target, quality of target lock, closure rate, and angle between the aircraft. The range, speed, guidance and fusing characteristics of the missile itself will also affect how likely it is that a shot will end either in a miss or a kill.

Choosing the Right Weapon

It has been said that if all you have is a hammer, then all of your problems will look like nails. However, using the wrong tool will rarely get the job done right. For example, firing a short-range missile

at a target from long range will surely fail. The missile will burn out long before it reaches its target. Likewise, using a long-range missile at too short a range will result in a miss if the missile cannot manoeuvre quickly enough to obtain an intercept or if the fuse does not have sufficient time to detonate.

While these statements may seem self-evident, it is important to check that you have the right missile armed and ready to fire before you pull the trigger. A wasted shot, even if you follow up with a successful one, may mean one less enemy that you can dispatch before you need to go to guns.

Obtaining A Solid Target Lock

The F-22 is a sophisticated platform that places an impressive array of sensors at your command. However, before you can shoot at something, both you and the missile need to be able to see it. An important item to consider here is the F-22's capability to carry missiles in its internal weapons bays. This reduces the observability of the F-22 to enemy radar, but presents a problem for certain types of missiles. It is not uncommon for short-range IR missiles to be carried internally. However, the passive guidance systems these missiles employ mean that you must first extend them out of the weapons bay in order that their seeker heads may get a 'look' at the target.

When you intend to fire an internally carried IR missile, you must press the trigger once to extend the missile out of the weapons bay. Only then will you be able to obtain a solid lock. Be sure to allow time for the missile's seeker head to zero in before pressing the trigger a second time to launch. If you switch weapons, the missile will be withdrawn back into the weapons bay and you will need to go through this two-step procedure once again. Obviously, externally carried IR missiles already have a view of their target and only one trigger press is needed to launch. Nonetheless, it is important for you to wait until a solid lock is achieved before firing. Be aware of these considerations and you will avoid making costly mistakes.

Radar guided missiles, whether they are carried internally or externally, derive all necessary initial guidance from the F-22's avionics. In this case however, it is the avionics, rather than the missile, which must have an active lock on the target prior to launch. Ensure that your EMCON settings are at Level 3 or higher before you pull the trigger. No missile launch will take place if you are at lower EMCON settings. Once the missile is in flight, you can return to a lower EMCON setting if you wish as the missile will rely on its own internal sensors to track the target while in flight.

Launch Altitude and Speed

As a rule, flying faster and higher will improve your chances of scoring a kill with long range missiles. Flying faster allows the missile to accelerate to terminal velocity more quickly, and flying higher reduces the amount of drag imposed on the missile. Combined, these factors serve to extend the effective range of the missile.

The secret here is to manoeuvre into the best firing position possible prior to launch. Make your decision as to whether or not to engage well enough in advance to take advantage of speed and altitude. If you commit to an evasive course of action and choose not to engage, you may find yourself in less than ideal launch conditions should you change your mind. There are times when it is more prudent to maintain a low profile. Use your best strategic judgment to make that determination. If you choose to engage, manoeuvre so as to do so on your terms by placing yourself in the best possible position. This brings us to the last consideration when seeking to improve your probability of scoring a kill.

Target Aspect Angle (TAA)

All other factors being equal, Target Aspect Angle is arguably the most important in achieving the most favourable launch conditions and the highest probability of a kill. Described simply, Target Aspect Angle is the difference between the Line Of Sight (LOS) from your aircraft to the target, and the target's direction of flight. A target flying towards your aircraft has a high TAA (near 180 degrees). One flying away from you has a low TAA (near 0 degrees). Intermediate aspect angles are characterised as either 'right' or 'left', based on where the target's nose points relative to the line of sight.

You can determine the aspect angle easily by checking the triangular airborne target icon in the HUD (Heads Up Display) or HMD (Helmet Mounted Display). The short line extending from the point of the triangle indicates the aspect angle. If the target is flying towards you, the line will be pointing downwards. Conversely, if the target is flying away from you, the line will be pointing upwards.

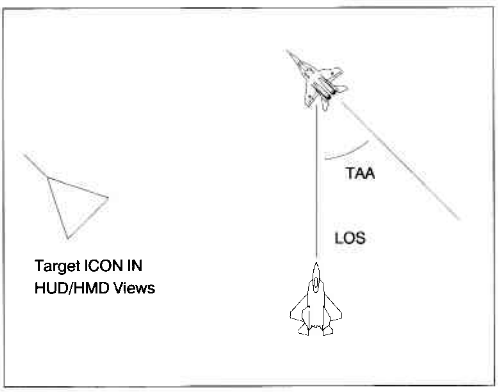


Figure 1.

In Figure 1, the target is at a 45-degree aspect angle to the left. Notice how the aspect line extending from the target icon as viewed through the HUD aligns with the target's flight path. This is an example of a 'rear quarter' aspect, and constitutes a perfect position from which to fire an IR guided missile.

It is important to note however, that TAA is completely independent of the direction your aircraft is facing. Aspect angle is calculated on the basis of your LOS to the target, not your flight path. A target with a low TAA will always be facing away from you, regardless of where it happens to be in relation to your aircraft. Of course, this can cause confusion when your line of 'sight' does not correspond to your line of 'flight'.

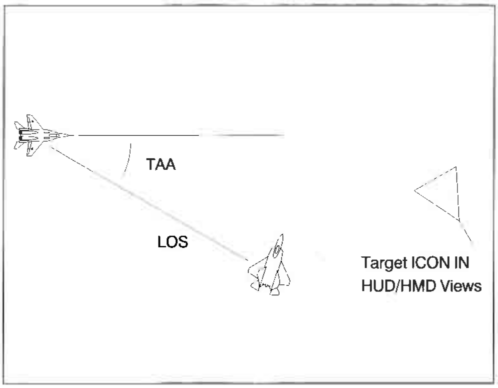


Figure 2

In Figure 2, notice how the target icon indicates that the bandit is at a high aspect, 150 degrees to the right. The target icon appears as it would if viewed through the HMD. However, because your nose is pointed away from the target, the aspect indicator does not align with target's flight path - at the moment. If you were to execute a 60-degree turn to the left, the target icon would not change, but your LOS would now correspond to your flight path and the TAA indicator would appear more intuitive. Incidentally, doing so would leave you with a 'forward quarter' aspect, an excellent position from which to fire long range, radar guided missiles.

All of the missiles modeled in F-22 ADF are 'all aspect' and can be fired irrespective of the target's aspect angle provided, of course, that the target is within range and seeker constraints. This is not to say that the missiles are equally effective at all aspect angles however. The optimum aspect angle for an attack depends on the weapon you use. For short range, IR guided missiles, a low aspect angle is preferred. This directs the missile's seeker head at the hot engine exhaust as much as possible. A high aspect angle is preferred for long-range, radar-guided missile attacks. This provides the greatest effective range for the missile, as well as the highest closure rate.

Aspect angles near 90 degrees, where the aircraft is flying at right angles to your LOS, are the least preferable and should be avoided. Short-range missiles fired at a target crossing in front of you must make very rapid and radical course changes to maintain target lock. This substantially reduces the missile's speed and increases the susceptibility to countermeasures. Radar guided missiles are also more susceptible to losing lock due to the low Doppler shift created by a target moving at right angles to the missile.

The AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)

As previously noted, two variants of the AIM-120 are modeled in F-22 ADF. The long range 'R' model powered by a ramjet engine, and the

medium range 'C' model, powered by a traditional rocket engine. Other than maximum range, there is little difference between the two in terms of use. Both are fully active, radar guided missiles capable of receiving updated target data from the launching aircraft while in flight.

The AIM-120 AMRAAM grew out of the need for BVR launch capabilities that short range, heat-seeking missiles could not provide. The earliest BVR missiles were the AIM-7 Sparrows of the 50's and 60's. The Sparrow utilised semi-active guidance, requiring the launching aircraft to maintain a radar lock from the moment of launch until impact. Unfortunately, guidance technology of the day could not deliver an accurate, reliable missile system. The Sparrow missile hit fewer than 10 percent of targets it was launched at during the Vietnam War. Despite upgrades and improvements, even the latest versions of the AIM-7, used during the Gulf War, scored hits on less than 40 percent of the targets it was fired upon.

By the late 70's, the military was looking for a new missile system - one that would provide fully active guidance and true 'fire and forget' capabilities. Of course, they also wanted a missile system that was both reliable and accurate. In 1981, Hughes Missile Systems was awarded a contract to develop the new 'Advanced Medium Range Air-to-Air Missile', and by 1991, the first AIM-120 AMRAAM was delivered to operational squadrons.

While the AIM-120 has only been fired a handful of times in anger by the U.S. military, it has an impressive record. Two Iraqi MiGs were downed by AIM-120s during and after the Gulf War. The first, a MiG-25 Foxbat, was shot down in late December of 1992 by an F-16C with an 'in your face' shot taken at high aspect. The second, a MiG-23 Flogger, was brought down by a low aspect shot as it tried to escape from an F-16C three weeks later. Over Bosnia, a Serbian attack aircraft was destroyed by an AIM-120 fired at extreme range. Despite the target aircraft's attempts to evade the missile by flying at extremely low altitude and dodging through mountainous terrain, the AIM-120 scored yet another kill.

In live fire tests, the AIM-120 has proven to be extremely effective even against extremely agile drones dropping large amounts of countermeasures. To the aircrews that carry the missile, it has earned the nickname 'Slammer' due to its accuracy and ease of use. Though only about two-thirds the weight and size of the AIM-7 Sparrow, the AIM-120 is a formidable weapon, capable of bringing down just about any aircraft it is fired against with deadly efficiency.

The maximum range for the 'R' variant is listed at 44 nautical miles. The 'C' model lists an effective range of 31 nautical miles. Of course, these figures depend on your speed, altitude, and the aspect angle to the target and are significantly reduced if fired on targets at low aspect.

Tables 1 and 2 indicate the maximum ranges at which a launch cue – a PK circle and shoot cue – is obtained for the AIM-120R and AIM-120C AMRAAM missiles when fired at high aspect targets.

Table 1: AIM-120R AMRAAM

Launch Altitude	Launch Speed	Closure Rate	Maximum Range
5,000 feet	420 knots IAS/0.70M	770 knots	33.5 nautical miles
5,000 feet	750 knots IAS/1.25M	1575 knots	43.5 nautical miles
10,000 feet	430 knots IAS/0.80M	850 knots	35.0 nautical miles
10,000 feet	710 knots IAS/1.30M	1600 knots	44.0 nautical miles
20,000 feet	400 knots IAS/0.90M	890 knots	36.0 nautical miles
20,000 feet	645 knots IAS/1.45M	1690 knots	45.5 nautical miles
30,000 feet	300 knots IAS/0.85M	835 knots	35.5 nautical miles
30,000 feet	535 knots IAS/1.50M	1690 knots	45.5 nautical miles
40,000 feet	425 knots IAS/1.50M	1675 knots	46.0 nautical miles

Table 2: AIM-120C AMRAAM

Launch Altitude	Launch Speed	Closure Rate	Maximum Range
5,000 feet	420 knots IAS/0.70M	770 knots	24.0 nautical miles
5,000 feet	750 knots IAS/1.25M	1600 knots	29.5 nautical miles
10,000 feet	430 knots IAS/0.80M	850 knots	25.0 nautical miles
10,000 feet	710 knots IAS/1.30M	1670 knots	32.5 nautical miles
20,000 feet	400 knots IAS/0.90M	890 knots	26.0 nautical miles
20,000 feet	645 knots IAS/1.45M	1740 knots	33.5 nautical miles
30,000 feet	300 knots IAS/0.85M	835 knots	35.5 nautical miles
30,000 feet	535 knots IAS/1.50M	1740 knots	34.0 nautical miles
40,000 feet	425 knots IAS/1.50M	1725 knots	34.0 nautical miles

The F-22's avionics will automatically determine the maximum possible launch range based on the current firing conditions, prompting you with a launch cue if the absolute minimum parameters have been met. Of all the variables affecting missile range, you will notice that closure rate has the greatest relative effect. As noted earlier, to strike targets at the maximum possible range, fly high and fly fast.

Minimum range for either variant is approximately 4 nautical miles, regardless of speed, altitude or aspect angle. Successful kills can be achieved at shorter ranges, down to approximately 2 nautical miles or slightly less for high aspect, 'in your face' panic shots. These are low

probability shots however, and should be avoided. Short-range, low aspect shots against manoeuvring targets are extremely difficult to achieve due to the missile's inability to 'turn the corner' fast enough to maintain lock on the target.

When launched, the AIM-120 will initially follow a ballistic trajectory towards the target. Once it reaches a point approximately halfway to the target, it will engage its active radar guidance systems to locate, identify and pursue the target for a kill. When firing at targets at extreme range, you can improve the likelihood of a kill by maintaining an active radar lock until the missile has passed the halfway mark. Doing so will allow the missile to receive updated target data from your F-22 prior to engaging its active sensors. Use the Attack MFD (Multi-Function Display) to follow the progress of your missile's flight.

Launching the AIM-120 in F-22 ADF/TAW is a relatively simple process. First, the target must be identified and tracked by the avionics and entered into the shoot list, (review Chapter 2, 'Avionics' for details on how to create and use the shoot list). Initial target acquisition may be made by onboard sensors, such as the radar, IRST (InfraRed Search and Tracking) or uplinked data sources such as other combat or AWACS (Airborne Warning and Control System) aircraft. Although you may acquire and track your target passively, you MUST engage your active sensors - select EMCON Level 3 or higher - before you can launch the missile.

The currently targeted aircraft will appear as a triangular icon surrounded by a circle in the HUD and HMD views, and as a highlighted icon in the Attack, Defence and Tactical Situation MFDs. Manoeuvre so as to point your aircraft towards the target, bringing it into view through the HUD. Use your padlock views to assist in this if the target is not already visible in the HUD.

The target data block and the range bar, visible in the HUD, will display the current range to the target. The F-22's avionics will determine the maximum effective missile range based on the current firing conditions. The range bar and caret provide an indication of the target's range in relation to the missile's effective firing envelope. The top of the range bar represents the missile's current maximum effective range. The bar becomes taller or shorter as missile range increases or decreases. The caret reflects how far away the target is and will be positioned above the top of the bar if the target is currently out of range. As range decreases, the caret will drop relative to the bar.

When the caret reaches the top of bar, the maximum allowable range conditions have been met. A circle will now appear in the centre of the HUD, which serves as a graphical indication of the current PK. As the circle increases in diameter, so too does the PK. At its maximum size,

the PK indicator circle will just about span the distance between the inside edges of the altitude and speed indicator boxes. As we have previously noted, PK is affected by a number of factors including range, speed, altitude, and aspect angle. Although these factors are considered by the avionics when calculating the maximum range, the PK indicator circle is based predominantly on the range to the target. The PK indicator reaches its maximum diameter - and consequently the missiles achieve their greatest lethality - at approximately one-half the maximum range.

What happens next depends on whether or not you have actively locked up your target. If you are approaching stealthily - using Manual EMCON Level 1 - you may wish to allow the range to close a bit before turning on the radar and launching a missile. If your active sensors are already engaged, two new indicators will appear in the HUD. The first is a small, solid square - the Missile Steering Cue. Since the AIM-120 follows a ballistic course during the initial part of its flight, the steering cue represents the 'best guess' as to where the target will be if it continues on its current heading. By centring the steering cue in the HUD, you will achieve the proper lead angle to allow the missile to acquire and intercept the target.

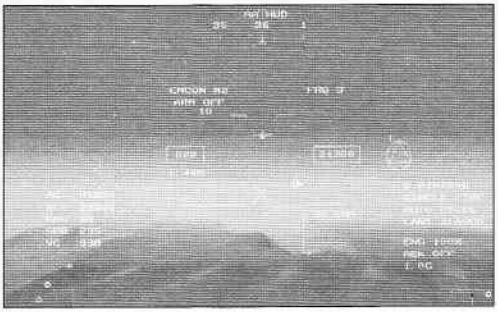


Figure 3

The second indicator is the shoot cue. The word 'SHOOT' will appear on the HUD when the avionics determines that 'reasonable' minimum launch parameters have been met. These include range to the target, missile seeker head limit and EMCON settings. The shoot cue normally appears approximately one, to one and one-half nautical miles inside the maximum range at which a launch cue – the PK circle – appears. Note that the appearance of the shoot cue only indicates that it is 'possible' to take a shot, not that it is necessarily desirable to do so. You must still make a tactical decision based on all the factors affecting PK before pulling the trigger. A high aspect angle, high speed, high altitude, and proper range all contribute to making the best of your missile launches.

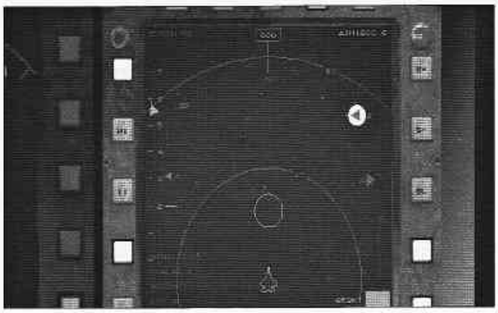


Figure 4

Figures 3 through 8 demonstrate how to set up a BVR kill using the AIM-120C. In the first image, a pair of MiG-31s has been targeted just under 50 nautical miles away at our one o'clock high and

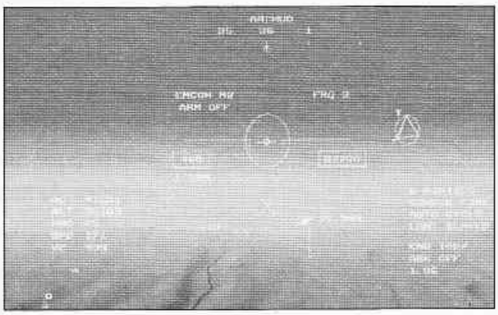


Figure 5

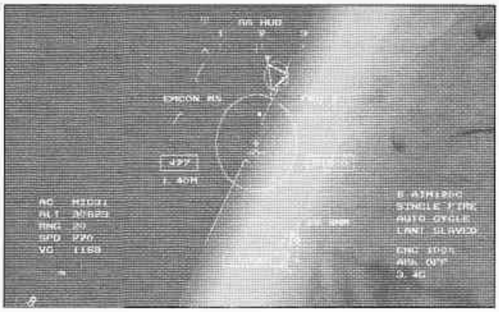


Figure 6

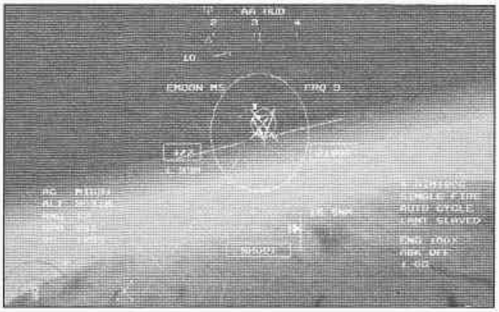


Figure 7

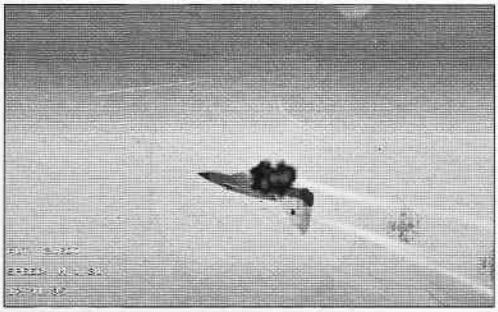


Figure 8

heading west. Using EMCON Level 2 to maintain a reasonable level of stealth, we will make a forward quarter approach from their ten o'clock position to get into firing position. Figure 4 shows how the situation appears on the Attack MFD as we set up the attack. In Figure 5, we have closed to 25 nautical miles and are in range to fire. The PK circle is visible in the centre of the HUD, but it is still relatively small, indicating a low probability of scoring a kill. Since we are as yet undetected, we will move in a bit closer before turning into the targets to fire. After another 10 seconds, we have reduced the range to 20 miles and are in perfect position to turn and shoot. Notice that the PK circle has grown to almost maximum size indicating that this we have our targets in the zone of no escape. As we make the turn, it is time to announce our presence, after all, we are only seconds away from launching missiles and stealth is no longer necessary or desirable. In Figure 6, active sensors have been engaged by switching to EMCON Level 5. A missile steering cue is now visible just ahead of the targets, as well as the 'SHOOT' cue at the bottom of the HUD. Time to let fly with a pair of AIM-120s. Figure 7 shows a pair of missiles streaking towards the enemy aircraft. The target icons now have an 'X' drawn through them to indicate that they have been fired upon. Despite dropping loads of chaff, the MiGs cannot evade the incoming missiles (Figure 8) Two missiles, two dead bandits!

The AIM-9X Sidewinder Short Range Air-to-Air Missile

The AIM-9, short range IR guided missile has been in service for over 40 years and is the most widely used missile for most air forces. Over 200,000 of these missiles have been built. They have been deployed on a wide variety of platforms, from helicopters to reconnaissance aircraft. A number of variants have been produced over the years as guidance, propulsion and warhead technologies have improved.

The AIM-9X variant modeled in F-22 ADF/TAW represents the state of the art for this small but deadly weapon. Improvements

include increased agility and range, through the use of thrust vectoring, improved control fin and rocket motor designs. Capable of executing manoeuvres at up to 60 G, the AIM-9X has the ability to attack targets that are significantly offset from the F-22's line of flight. This 'off boresight' capability, combined with the F-22's HMD targeting system allows you to attack aircraft located anywhere within a broad sweep of sky. As modeled in F-22 ADF, the AIM-9X can be fired at targets up to 60 degrees off the nose of your aircraft.

Maximum effective range for the AIM-9X is listed as 10 nautical miles, however under high speed, high aspect conditions the range may increase to as much as 13 nautical miles. Under low aspect launch conditions, effective range will be somewhat less than 10 nautical miles. As with the AIM-120, the avionics will calculate the maximum range based on the current launch conditions. Minimum range is as little as a quarter mile under low aspect conditions. 'In your face' shots at close range with the AIM-9X are very effective, however, due to the high closure rate, allow about 1 nautical mile of separation. Both to give the missile time to manoeuvre, as well as to give you enough manoeuvring room to avoid flying into the ensuing debris cloud.

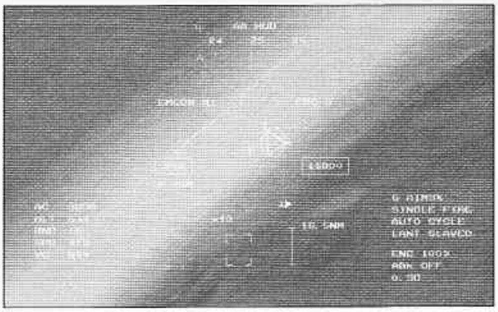


Figure 9

Since the AIM-9X is an all aspect weapon, you do not need to manoeuvre behind the target to lock on and fire. A low aspect, or 'rear quarter' shot is still the best bet for scoring a kill however, as this exposes the missile's seeker head to the hot exhaust from the target's engines. Initial acquisition of the target can be made with your onboard radar or IRST, as well as with uplinked data sources from other aircraft. No actively emitting sensors are required to lock on or launch the AIM-9X, allowing this missile to be used while maintaining complete stealth.

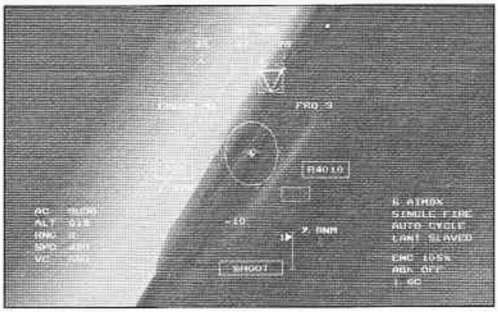


Figure 10

Firing the AIM-9X is a simple process. First, designate the target using whatever sensors you wish and add it to a shoot list. This provides initial cues to the missile and slaves the seeker head in the direction of the desired target. As with the AIM-120, the currently selected target will appear in the HUD/HMD as a triangular icon surrounded by a circle and as a highlighted icon in the Attack, Defence and Tactical Situation displays. If necessary, use your padlock views and

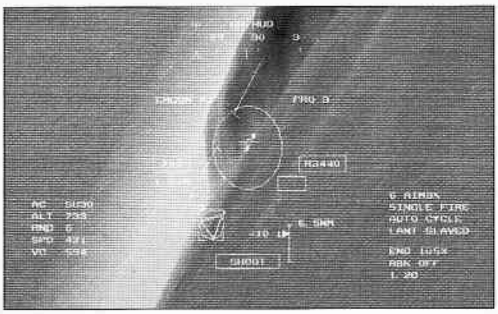


Figure 11

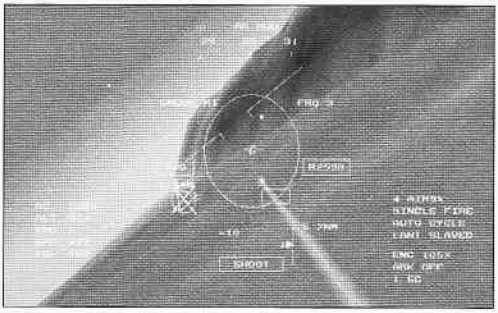


Figure 12

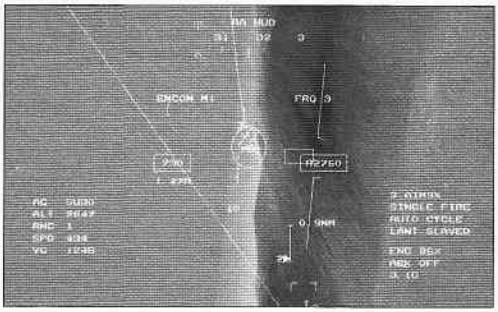


Figure 13

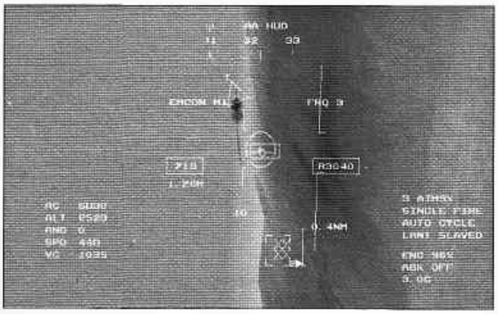


Figure 14

manoeuvre so as to position the target in the HUD/HMD.

A range bar and caret will appear in the HUD/HMD that functions identically to those described for the AIM-120. In addition, a broken box will move across the HUD to indicate that the missile's seeker is searching for the target. If you are carrying the AIM-9X internally, you will not see the seeker box until the missile is extended out of the weapons bay. Press the trigger once to open the weapons bay and extend the missile into the slipstream, allowing the seeker head to 'sniff the air' and get a view of the target.

Once the target is within maximum firing range, the PK indicator circle and missile steering cue will appear. Again, these function identically to their AIM-120 counterparts. Wait until the seeker box is flashing over the target and the 'SHOOT' cue appears. If possible, wait until the PK indicator circle is maximised before launching. Manoeuvre to centre the steering cue in the HUD, then fire. If all goes according to plan, you will soon have one dead bandit and one more silhouette to paint under your canopy rail.

Figures 9 through 14 illustrate a stealth attack on a pair of Su-30s. Using passive sensors throughout the intercept, these pilots only learn of our presence when Sidewinder missiles are streaking towards their tailpipes! In the first image, we see the targets crossing low in front of us, just over 16 nautical miles out. Notice the missile seeker box at the bottom of the HUD. Although static in this image, it sweeps across the HUD in search of a hot target. Externally mounted missiles have been selected for this attack, however if they were carried internally, the seeker box would not be visible unless the missiles are first extended out of the weapons bay. Whenever you are pursuing an attack with Sidewinders, make sure you look for the seeker box as an indication that a missile is ready to fire. Using lag pursuit to get in behind the targets, we have closed the gap significantly by the time indicated in Figure 10. The targets are now in range and the seeker head is fixed on the target icon. A 'SHOOT' cue has appeared along with a PK circle and missile steering cue, visible in the upper right-hand corner of the HUD. Having manoeuvred to the enemy's rear quarter, it is now time to turn in for the kill. In figure 11, we have pulled our nose into lead pursuit, bringing the steering cue

into the centre of the HUD. We have a good lock, a good PK, now is the moment - FOX 2, FOX2! A pair of missiles inbound is quite a wake up call for these unfortunate pilots (Figure 12). Ten seconds later, two Su-30s are titanium trash as the missiles guide true to their targets (Figures 13 and 14).

The M61A2 20mm Cannon

The F-22 is equipped with a M61A2 rotating 6 barrel Gattling gun mounted above the right wing root, and an ammunition drum which contains 1,760 high explosive rounds. Capable of firing 60 rounds per second, the M61A2 packs a lot of firepower. The 'A2' is a variant of the venerable M61 that is both lighter than the original and features longer, composite fibre wound barrels for improved accuracy.

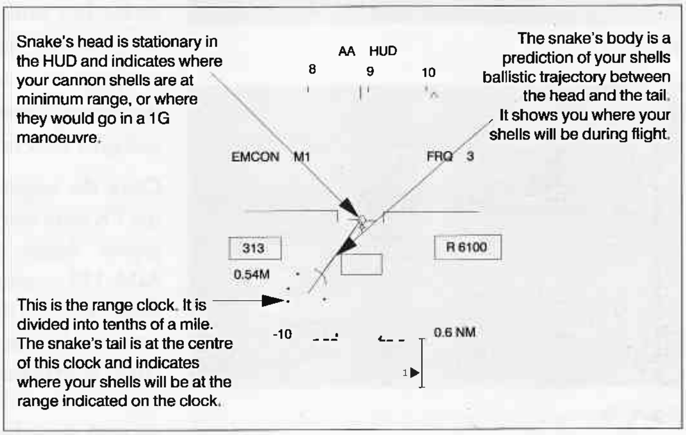


Figure 15

Guns have been present on nearly all combat aircraft since World War I, although in this day of guided missiles, their role is somewhat diminished. Effective only at very short range, the gun is a last ditch weapon in most air-to-air encounters. Useful when missiles are unavailable, you cannot return to base to rearm, and combat is unavoidable, but definitely not the weapon of first choice. Nonetheless, the M61A2 is a powerful weapon; capable of downing any aircraft you may encounter when properly used.

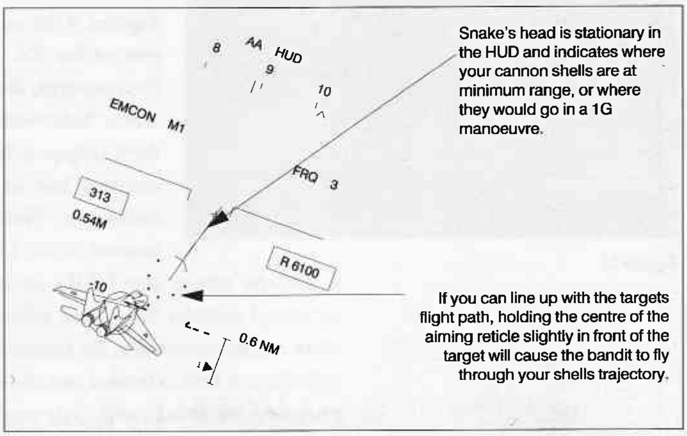


Figure 16

Both Air-to-Air and Air-to-Ground operations are supported, with aiming modes specific to each task provided in the HUD and HMD. Since our focus in this chapter is Air-to-Air weaponry, we will examine the use of the M61A2 in this role.

The gunsight modeled in F-22 ADF/TAW is a predictor gunsight, consisting of an aiming reticle and a predicted flight path line tied to the centre of the HUD. The aiming reticle doubles as a range indicator when attacking targets on which a lock has been established. Target acquisition and selection is performed in the same way as for missiles, using a shoot list to designate targets of interest.

Maximum range for the M61A2 cannon is 2 miles, although firing with accuracy is extremely difficult at ranges beyond one mile. There is no minimum range, although you should allow sufficient separation to manoeuvre away from any debris cloud created by the impact of the shells.

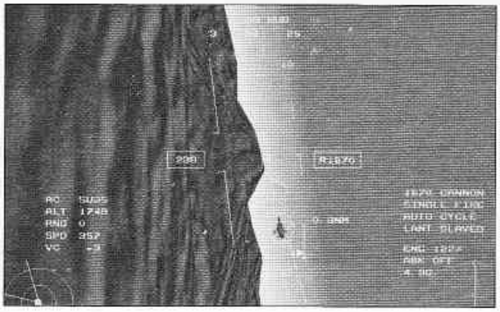


Figure 17

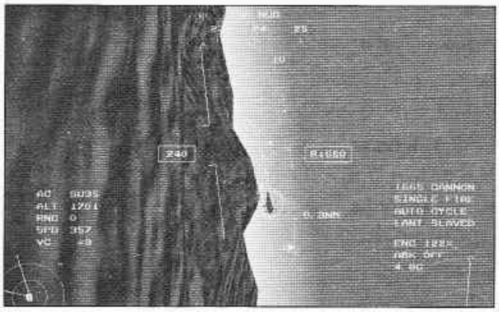


Figure 18

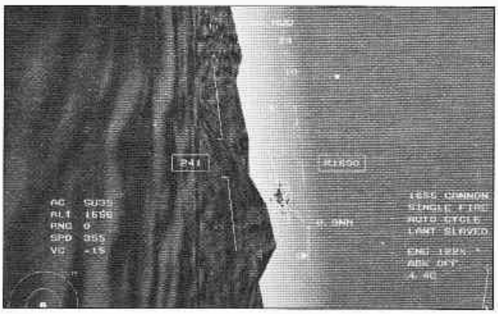


Figure 19

The predictor gunsight has been nicknamed 'the snake' by combat pilots because of its convoluted movements during manoeuvres. The reticle represents the 'tail' of the snake, with the predictor line forming the body. To use the gunsight, drag the body of the snake through the intended target, aligning it with the target's flight path. When the reticle is centred on the target, pulling the trigger will result in a hit. The centre of the reticle represents where the bullets would land if you had fired them one 'time of flight' (TOF) ago, and is keyed to the motion of both your aircraft as well as the the target's. Assuming that you and your target maintain a constant flight path, centring the reticle on the target will ensure a hit. Figures 15 and 16 illustrate the basic items found in the M61A2 gunsight.

While this sounds simple enough, in practice it takes skill and patience to perfect the technique. Enemy pilots are rarely so obliging as to provide a stable target, and any manoeuvres will send the snake whipping around the HUD. Gentle movements of the control stick are critical to lining up your shots.

The key to successful gunnery is to first, get up close and personal. Gunnery is easiest at close range - one half mile or even less. Get behind the target and fly close enough so that its wingspan, as viewed through the HUD in normal viewing angle, is at least as wide as the reticle. Manoeuvre so that the reticle is slightly ahead of the target's flight path - 'in lead'. Use one to two diameters of the reticle as a

rough guide. Align the snake with the target's flight path as closely as possible. If the target is manoeuvring, you can use the vortices trailing off the target's wingtips as a visual aid for the alignment. When you have positioned the reticle, relax the back pressure on your control stick slightly, just enough so that the target starts to move up towards the reticle. As the target enters the reticle, pull the trigger and continue firing as he passes through circle.

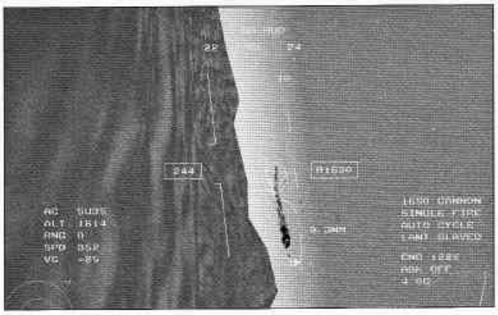


Figure 20

Firing from one of the fixed forward views is easier than using the padlock view since your frame of reference remains stationary. By the same token, normal views are easier than wide-angle views because you have a more detailed picture of the target. However, be aware that whenever you change from padlock to fixed views, the gunsight will reset itself and will require at least a second or two to stabilise. As a result, shooting from padlock view is a skill you will need to practice and perfect. The added situational awareness that padlock view provides is well worth the added difficulty it creates for gunnery. In addition, if you can shoot from padlock view, you will be better able to take advantage of snapshot opportunities.

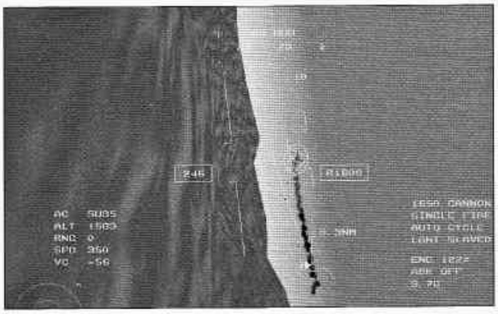
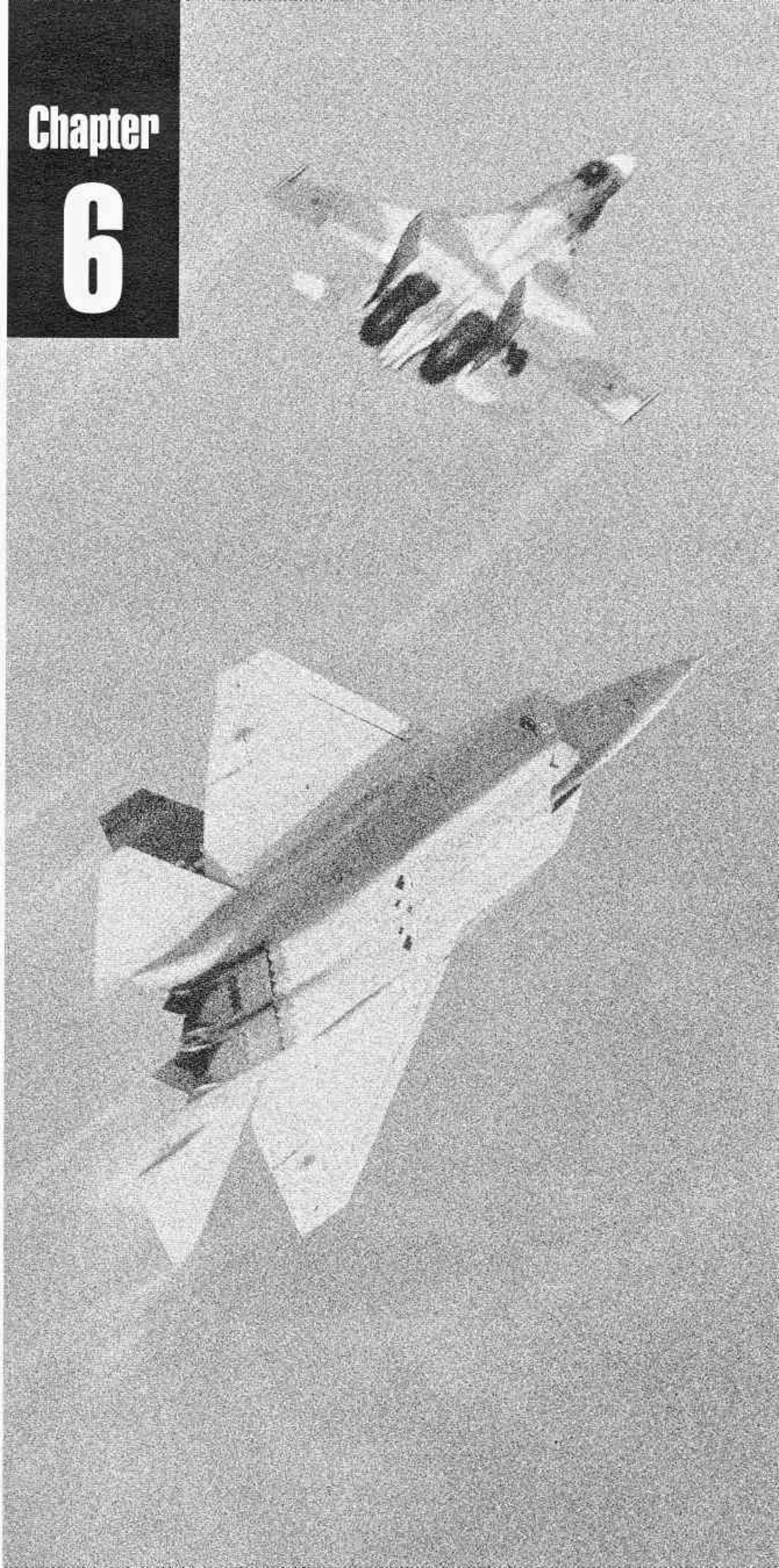


Figure 21

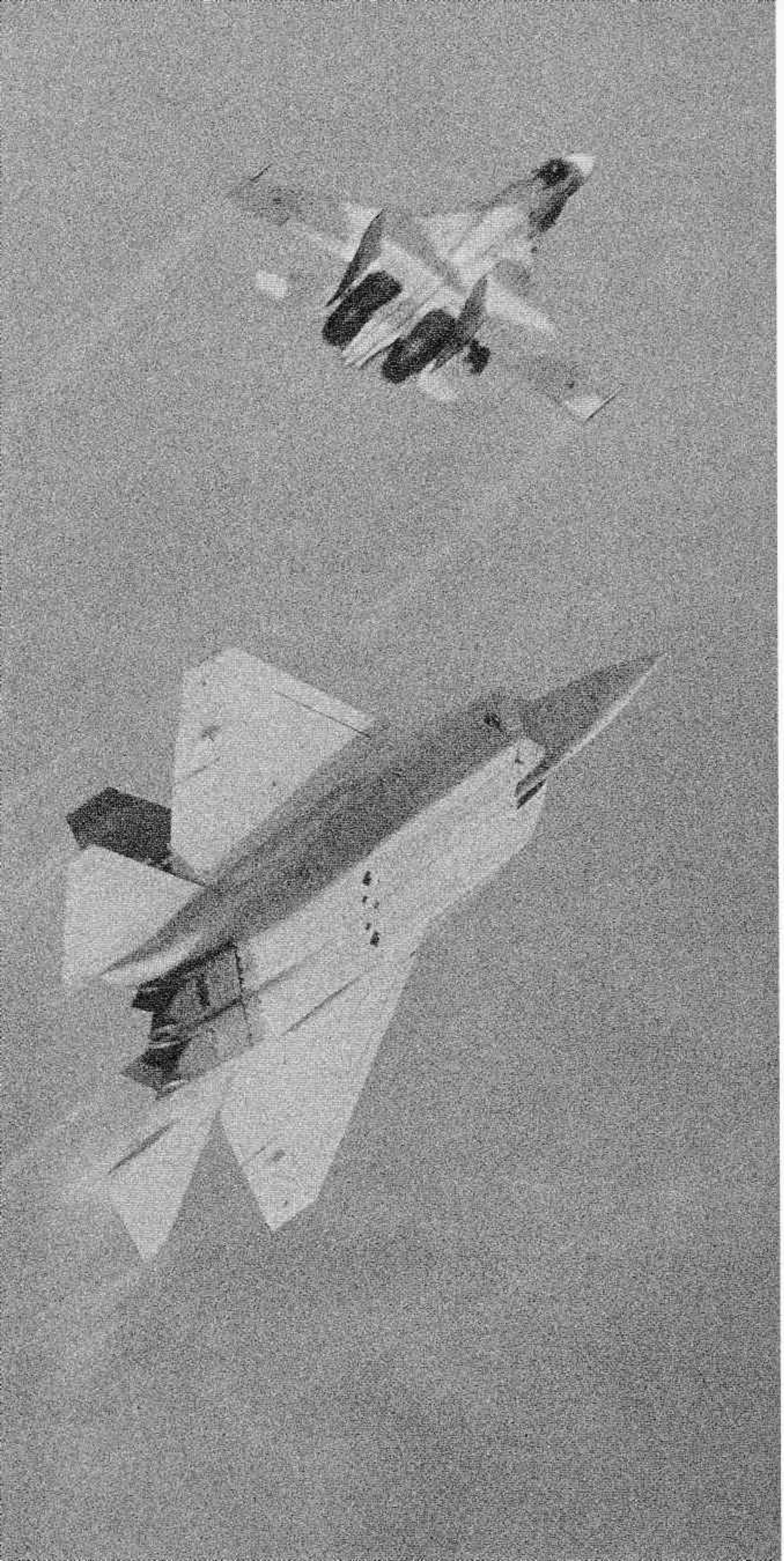
The gun camera footage (Figures 17 through 21) illustrates the desired technique. In the first image, the reticle is in perfect position just ahead of the Su-35. Notice how the snake is aligned with the bandit's flight path, using the wingtip vortices as a visible reference. Gently releasing back pressure, pull the trigger as the bandit flies into the reticle. In Figure 18, cannon shells are already in flight as the bandit crosses the gunsight reticle. Continue firing as the bandit flies through the reticle. The impact of our shots is registering in Figure 19. The last two images capture a mortally wounded bandit, out of the fight and soon to be a smoking hole in the ground after taking 20 well-placed rounds (Figures 20 and 21).

Chapter 6



A2A Combat

- AVIONICS
- THE ENGAGEMENT
- ENGAGEMENT TACTICS
- BASIC FIGHTER MANOEUVRES



CHAPTER 6

A2A Combat

Ever since the Red Baron took to the air, air combat has experienced a series of evolutionary and revolutionary developments. Many have been minor, while others have been very significant. Most changes have been evolutionary in nature...meaning progress is made along a path that is readily predictable. An example of this is the continued development of the piston engine from the Sopwith Camel WW1 radial to the post-WW2 radials found in the Hawker Fury and Douglas SkyRaider. Others have been revolutionary, meaning a discovery or development that clearly led to a new dimension in fighter operations. An excellent example is the introduction of the jet engine. Numerous other examples of revolutionary developments in air combat come to mind, airborne radar, pressurised cockpits, beyond visual range A2A missiles, to name a few. Each one in its own way gave rise to a great leap forward in offensive potential. Each expanded the playing field far beyond what had been the norm of their time. F-22 ADF/TAW allows you to make a similar leap forward in air combat simulation. Just as the real F-22 Raptor embodies new technologies that have re-defined aerial warfare for the next century, our virtual F-22 takes you to a new level of offensive sophistication and co-operative game play.

F-22 ADF/TAW has been designed to provide several levels of player involvement in air combat operations. From relatively simple training missions to complex multi-player scenarios, the enhanced game play in this simulation meets and exceeds the expectations of simulation pilots of every experience level.

This enhancement of game play does not come, however, without a price to be paid. That price is the time and effort that the simulation pilot must put into the study of how F-22 ADF/TAW keyboard functions, viewing systems, and avionics integration enhance both long and short range Air Combat Manoeuvring (ACM). The purpose of this chapter is to provide you with that insight. From these pages you will gain that all-important competitive edge that will transport you from average participation to exceptional achievement.

Overview

F-22 ADF/TAW offers six levels of air combat game play: training missions (Simulator), instant action (Quick Combat), scripted scenarios (Tour of Duty), head-to-head competition (Multi-Player), battlefield command and control (AWACS Commander) and in TAW, Campaigns. Each level presents its own unique challenges. In meeting these challenges, you will need to learn how to maximise your ability to master the following simulation skills:

1. Long range target detection using both on and off-board systems.
2. Co-operative tactics.
3. Undetected weapons employment.
4. Supercruise and thrust vectoring techniques.
5. Basic Fighter Manoeuvres

Lets return for a moment to the days of the Red Baron. Air combat was simpler then, you can think of it as a 'head out of the cockpit', visual, gun-only environment where engagements quickly degenerated into single dogfights. Regardless of the rudimentary sophistication of this type of air combat, an evaluation of kills made one thing clear. Most victims never saw their attacker. This fact has remained a constant of air combat ever since. In F-22 ADF/TAW, you will prove that axiom again as you take full advantage of on and off-board avionics systems to make a stealthy and deadly approach to your unwitting victim. Lets begin then with a look at the avionics systems in F-22 ADF/TAW.

Part I Avionics

The F-22 ADF/TAW simulation offers you superior 3D graphics, a realistic flight model, and an outstanding range of player views, but it is the integration of a combat-oriented avionics package that sets this simulation apart from the others. F-22 ADF/TAW avionics are far more than a detailed instrument panel. Instead, the avionics package will be your partner as you direct and engage in the overall air combat plan. In F-22 ADF/TAW, your aircraft avionics are combined with outside sensor sources to provide an all-encompassing 'big picture' of the air war arena. In this simulation, this combination is known as 'sensor fusion,' meaning the fusion or joining of multiple informational data inputs into a single, easily interpreted battle management presentation.

This presentation replaces the traditional radar scopes and radar warning receivers of less-sophisticated fighters. F-22 ADF/TAW advanced technology has relieved the pilot of time-consuming manual radar operation as well as manual interpretation of threat warning systems. Instead, these operations are automated and are presented on the cockpit displays in a 'God's eye perspective'. Rounding out this 'big picture' of the battle plan is the inclusion of surveillance information from your partners in the battle arena, your wingmen and AWACS.

Your proficiency in using the 'big picture' will be the key to your success in the initial stages of an air combat engagement. Once the battle is joined, you will maintain the offense as you use the cockpit viewing systems to 'mop up' the remaining bandits.

Proficiency in using the avionics package in F-22 ADF/TAW is the major aspect of this simulation's gameplay that sets it apart from all others. In a real sense, your use of the multi-function displays and the manner in which these displays enhance your overall situational awareness (SA) is what gives F-22 ADF/TAW a 'strategic' feel. By 'strategic,' we mean your ability to command the entire battle arena. You implement your strategic plan at long range - well beyond the sensory range of your enemy. Depending on the type of gameplay that you have chosen, you will be able to take advantage of your own on-board avionics as well as benefit from input from off-board sensors such as AWACS or other flight members. This chapter will provide

you with the operational knowledge - both strategic and tactical - necessary to take full advantage of your avionics package. This information will include suggested techniques on how to employ the F-22 ADF/TAW avionics and weapons in BVR as well as visual air combat. These techniques are intended to be a guide for the pilot new to F-22 ADF/TAW. Consider them only as a point of departure. As your skill and proficiency increase, you will develop techniques of your own. We will provide a 'walk before run' approach that will minimise the time you need to become comfortable with the simulation. Once you are at ease with the multiple displays available to you, your game play will take you to a level of enjoyment that no other air combat flight simulation can provide. With that in mind, let's get to the action!

A2A Avionics - The Need For Automation

We must always remember that the multiple systems in F-22 ADF/TAW are intended to be operated automatically by computers. This is necessary in order to take full and best advantage of each A2A weapon system. The foundation of the automated avionics system is the EMCON (Emissions Control) system. EMCON acts as an asset manager for the pilot by providing specific levels of automation for a given tactical situation. In automatic operation, EMCON decides what this level should be. In manual mode, you make this decision.

F-22 ADF/TAW avionics permit you to make an unobserved approach to your target, launch your selected weapon, and then safely disengage. Should the tactical situation require that you enter the close in visual arena, these same avionics provide superior situational awareness and flexibility in short range weapon employment. These avionics consist of three major parts - detection systems, data presentation systems, and communication systems.

Detection Systems

These consist of the radar, IRST (Infra-Red Search and Track), RHAW (Radar Homing and Warning), IFF (Identification Friend or Foe), and MAW (Missile Approach and Warning) systems. You configure these systems by selecting an EMCON mode of operation. Each of these systems may be operated in an automatic or manual EMCON mode. In automatic operation, F-22 ADF/TAW Artificial Intelligence (AI) will determine the EMCON level. This will, in turn, determine each system's status and operational range as a function of the enemy's ability to become a threat to you. In manual, however, you will make that determination based upon your assessment of the tactical situation.

Presentation Systems

Your A2A presentation systems consist of the Heads Up Display (HUD), the Helmet Mounted Display (HMD), and the Multi Function Displays (MFDs). The amount of data presented on these displays vary with the EMCON level and the type of weapon that you have selected.

The displays that will demand most of your attention in the initial stages of your attack are the Attack, Situation, and Defence MFDs. The Defence MFD gives you a 360 degree look around your aircraft and provides the best overall SA, while the Attack and Situation MFDs concentrate on the airspace forward of your wingline. For long range intercept and attack, your HUD and HMD will take a back seat to the MFDs. The HUD and HMD only provide a narrow field of view and are best used when in visual range of your target or when under attack by an enemy who has a visual contact on you.

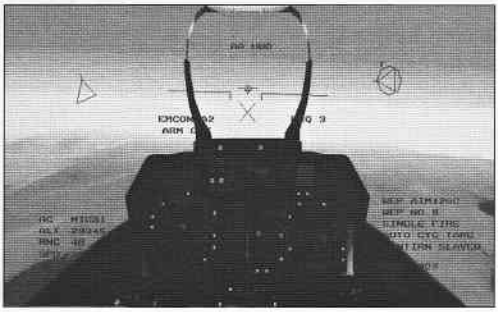


Figure 1 - Presentation Systems

Communication Systems

These consist of your UHF radio and your data link. While your UHF radio is obviously a manually operated system, the data link is an automatic transmit and receive form of radio communications that is very resistant to enemy detection and interrogation. Historically, data link has been used to transmit intercept information from ground radar stations to airborne fighters. In F-22 ADF/TAW, this capability is provided by the AWACS. Most of your tactical intercept data will come from an AWACS data link transmission.

Your UHF radio gives you the ability to command the battle arena at long distance, arrange your formation members, and assign and order weapon launches on the enemy.

At this point, one thing should be clear - the avionics program in F-22 ADF/TAW is comprehensive, detailed, and complex. For you the question is simple. What does all of this do for you, and how do you make it work to your best advantage? The next section will discuss specific tactics and techniques for employing the F-22 ADF/TAW in aerial combat.

Part II The Engagement

An engagement consists of three parts: the intercept, weapons employment, and the disengagement. Let us begin this discussion by looking at overall intercept considerations and concepts.

The Intercept

Every successful air combat engagement begins with a plan tailored to achieve the mission objective. That plan consists of four main parts... first you develop the plan, then you communicate it to your flight members. In the third step, you implement the plan, and lastly, you disengage from the plan. In gameplay, as in real life, success in air combat comes to those who have a firm idea of what they want to achieve and know how to go about doing it.

Developing The Plan

For gameplay within the simulation, mission objectives are spelled out in the mission descriptions. In most cases, as in real life, you will be given a briefing on friendly support forces as well as expected enemy forces. Do not be surprised if your offensive potential seems to be barely adequate for the task at hand. You will have to make every shot count. In the real world, successful fighter pilots have more than just 'golden hands', they also have another attribute that is just as important. It is called 'headwork'. Headwork is the mental calculation that balances your strengths against the nature of the threat and then develops a plan to meet your mission objectives. In F-22 ADF/TAW, you too will need to have a plan to meet your mission goals.

In developing your plan, you will take into consideration the following criteria:

1. You are assumed to be proficient in F-22 ADF/TAW systems operation.
2. You know how many weapons your flight has.
3. You have a good knowledge of the level of enemy strength.
4. You have a back up plan in the event things do not go right.

In real life, the time to develop the plan is not after stepping into the cockpit! This is just as true in the simulation, so before starting the action, give yourself a few minutes to think over the above criteria. As someone once said, 'Remember the 5 P's...Prior Planning Prevents Poor Performance'. Once the action begins, time will become your enemy just as much as the red triangles on your HUD or MFDs. Here are a couple of tips to give you a little more time to deal with tactical situation as it unfolds. These two 'crutches' will help you learn the ropes of F-22 gameplay. As your proficiency increases, we expect that you will need them less and less.

1. **Use the Pause key to stop the action.** While paused, you will still be able to switch internal and external cockpit views. You will be able to look at all the MFDs and actuate their function buttons. You will be able to use the UHF radio while paused.

2. **Use the autopilot.** In the early stages of an intercept, you can use the heading hold feature to maintain 'hands off' flight while you are occupied with other tasks. Inexperienced pilots may find that using the track function of the autopilotgives them the time to analyse how the AI flies the intercept.

Communicating The Plan

F-22 ADF/TAW has a comprehensive set of UHF radio commands that you can use to direct your flight to meet your mission objectives. You have four types of communication that can be used in A2A missions. Besides the obvious opportunity to talk to your flight, you may also communicate with the AWACS, your airfield, or the refueler. Depending on the type of gameplay, all or some of these may be applicable to your plan. Remember, the UHF radio is operational only in EMCON levels 2-5.

Your attack plan should include the following considerations: formation assignments, target assignments and sharing, weapons employment, and disengagement procedures. Be prepared to communicate these in the initial stage of the attack.

For Multi Player or H2H game play, you will use the keyboard to type your message in plain text to your flight.

Implementing The Plan

Well, as the old saying goes, this is 'where the rubber meets the road'. This section will discuss a number of pre-engagement considerations. We will propose solutions to strategic and tactical problems, as well as offer techniques to help you along.

Getting Started - Setting The Stage For the Intercept

In the real world, a flight leader will initiate his attack plan by taking full advantage of any environmental considerations that may be a factor in his mission. In this simulation, you, to a limited degree, may do the same. Here are some thoughts to keep in mind:

1. **Sun Angle** - Time of Day. As a rule, try to attack with the sun at your back. This way, your enemy will have to look into the sun for you. Sun blinding is well modeled in F-22 ADF/TAW. Since the simulation can set the time of day, this can be an advantage to you.

2. **Geographical Boundaries.** A country's geographical border may offer you the opportunity to protect your flank. Putting this boundary at your rear may deny the enemy that airspace to manoeuvre in.

3. **Terrain Elevation.** If you have chosen a low altitude ingress route, you may be able to use rising terrain to help mask you from enemy radars. Regardless of the enemy's radar range, it cannot see through rock. Tuck yourself and your flight down in the valleys and use AWACS to keep informed of the threat's position. Once you are in a clear position to attack, then you can climb up for the kill.

4. **Position of Other Friendly Forces.** Use the Situation MFD to note the position of AWACS and additional friendly aircraft. Develop a plan that includes other friendly fighter assets in your attack and, at the same time, protects support assets such as AWACS and tankers.

Your Formation - Optimised For Air Combat

F-22 ADF/TAW offers you a number of formation options. The default formation for your flight usually positions your wingman behind you on an approximate 45 degree angle. This formation is known as 'extended fighting wing' or 'wedge.' It offers flexibility and relatively good lookout, but has the downside of tying the wingman to the leader. This reduces some of the offensive potential of the flight and makes it easier for the enemy to target you and acquire you both visually. On the other hand, it is a good formation to use at low altitude when terrain avoidance is an issue.

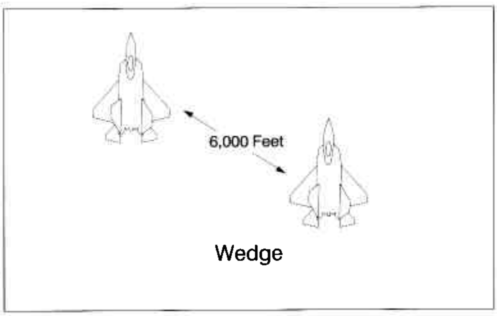


Figure 2

Aside from the default formation, two other formation types are particularly suitable for air combat. These are the Card and Sweep formations. Card is a four aircraft formation, while Sweep may be flown by any number of aircraft. Regardless of which formation you choose, always space your flight members apart, both horizontally and vertically. Typical horizontal spreads are 6,000 feet, and typical vertical splits are 3,000-5,000 feet.

1 **Card.** This name comes from the rectangular shape of the formation... imagine a playing card with an aircraft at each corner. In this formation, you want to space your wingmen out at least one mile from each other. We should remember that the mutual support coverage provided by the F-22 avionics allows us to space our aircraft farther apart than may have been possible in the past. Card is a good formation for all engagement altitudes. Card is a 50/50 trade off between offense and defence, and is a good formation to use en route to the engagement area. Once in the engagement area, however, you should change to a more offensive formation. That formation is Sweep.

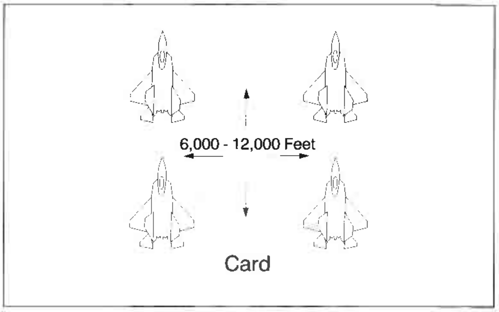


Figure 3

2 **Sweep.** This is a line abreast formation with at least one mile spacing between flight members. Sweep allows all flight members to be up 'on the line' prior to an engagement. Sweep allows your full avionics suite to be directed at the enemy. Splits, drags, and brackets are easily managed from the Sweep position.

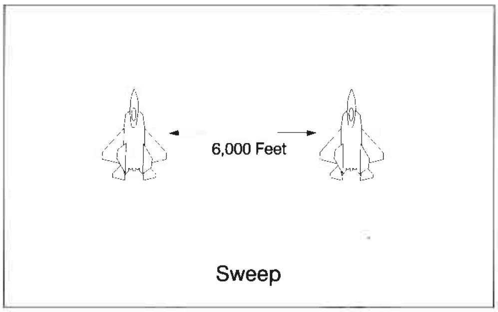


Figure 4

The other formation types offered in F-22 are Deuce, Strike, Fingertip, and Vic. Deuce and Strike are specialised formation types optimised for air-to-ground missions, while Fingertip and Vic are 'travel' formations that have little relevance to air combat operations. We recommend you use Sweep as your primary attack formation, with Card and the default formation as your alternate choices.

The Fence Check

Another technique from the real world that you can use in implementing your plan is to always begin an engagement with a quick review of important items necessary for the attack. The term 'fence' refers to the imaginary line between the good guys and the bad guys, once you cross the 'fence,' you are ready for action. Here are some items that you might want to double check before you get into the heat of battle:

1. **Fuel.** This is an important check particularly if you are re-attacking from an earlier engagement. Your fuel status is read from your Systems MFD. A good technique is to predetermine a minimum fuel quantity level for disengaging from the battle. This level is known as 'bingo' fuel. Timely fence checks allow you to avoid going below bingo fuel status.

2. **Formation.** Set your formation after considering environmental conditions and mission objectives.

3. **EMCON.** Your study of the avionics sections has stressed the significance of the EMCON level. Always know your EMCON status. Significant limitations in weapons operation and threat detection and warning accompany EMCON levels.

4. **Navigation.** Using mission objectives, geographical boundaries, terrain elevation, and threat capabilities, navigate your flight to optimise your offensive potential and minimise any weaknesses. Protect support assets. If available, plan your route to include other friendly fighter forces.

5. **Communication.** Make sure you have communicated your attack plan to your flight. Obtain the latest threat information from AWACS or other off-board sources.

6. **Weapons.** Nothing is worse than pulling the trigger and having the wrong weapon selected, or worse, having nothing happen at all. Your HUD and your MFDs will tell you which weapon you have selected. Check your System MFD to confirm how many weapons you have remaining and where they are loaded. This is your last chance to make sure you have everything set up correctly, take the time to do it. Air combat history is filled with stories of pilots who missed kills because of incorrect avionics configuration or wrong weapons settings.

The Stealth Approach - Avoiding Detection

The F-22 Raptor is the first air combat fighter that can stake a claim for being a true low-observable or 'stealth' aircraft. Its shape and construction methods have reduced its radar signature to very minimum levels. This is true of the real world F-22 and it is true of this simulation. F-22 ADF/TAW programming has taken this into account, and you should fly the F-22 with this in mind. Whenever possible, you want to present the smallest possible aircraft profile to the enemy. Do this and you present the smallest Radar Cross Section (RCS) for his avionics to detect. This then results in delaying or preventing his awareness of your presence until it is too late. The best

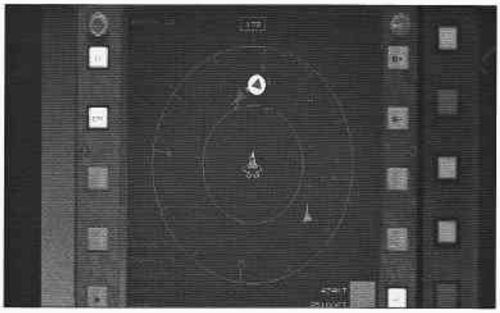


Figure 5a - MFD view of Pure Pursuit

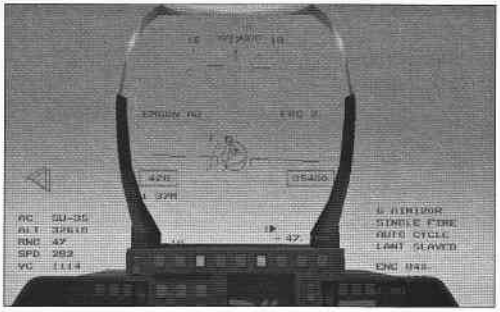


Figure 5b - HUD view of Pure Pursuit

way to accomplish this is to keep your flight pointed at the enemy as long as possible. When turning, point your nose directly at the enemy in order to fly a 'pure pursuit' flight path. When using the MFDs, keep your aircraft symbol pointed right at the target. When using the HUD, keep the targeted bandit in the centre.

A second method of achieving low radar visibility is to show the enemy a side view of your aircraft. The side aspect of the F-22 has a reasonably low radar cross-section. In addition, presenting this side perspective to the enemy allows you to take advantage of the difficulty his search radar has with targets flying on a 90 degree crossing angle. This is known as 'beaming' the enemy. Most of the enemy aircraft in F-22 ADF/TAW use a radar technology known as 'pulse-doppler (PD).' Rather than detecting an actual echo return from a target, called a 'skin paint', PD radars instead measure the relative change in velocity between their aircraft and others. If another aircraft is crossing in front of a PD radar on a 90 degree angle, then that aircraft has a closing velocity equal to the PD radar's airspeed. To the PD radar, this looks just like a ground return. Since the PD radar computer ignores ground returns, then that aircraft is not displayed on the PD radar scope. This feature allows PD radars to be unaffected by ground returns, and is the main reason for their 'look down-shoot down' capability. At the same time, it limits their capability to detect and track targets on the beam. When you can no longer fly in pure pursuit, try to beam the enemy for as long as possible.

A third method of minimising the chance of the enemy detecting your flight is achieved through altitude separation between your and your wingmen. Enemy radars scan relatively narrow bands of airspace when they are in search operation. You can deny them acquisition by flying your chosen formation with an altitude split as well as lateral spacing. Use a vertical split of at least 3,000-5,000 feet or more. When making this split, take the sun position and enemy altitude into consideration. Whenever possible, place your wingmen opposite the position of the sun or enemy relative to you. For example, if the enemy flight is below you, position your wingmen above your altitude. This allows them to look through you into the threat. In the same manner, if the sun is a factor, place your wingmen on your down sun side. Assuming that the enemy would like to attack out of the sun, you want your wingmen looking into the threat.

Maintaining Stealth By Manoeuvring

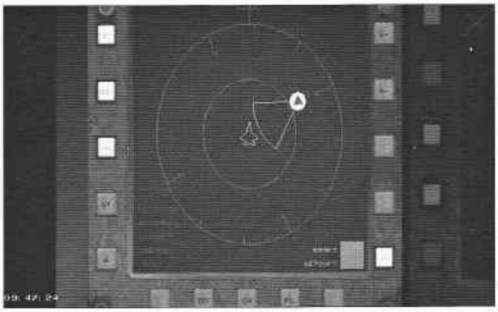


Figure 6 - Radar Scan Pattern

The enemy is going to become aware of your presence through one of two ways. He is either going to detect you with his own radar, or you are going to alert him by radiating electro-magnetic energy that his sensors can pick up. As for the latter, a good EMCON plan will help reduce this possibility. Looking then at his ability to acquire and track you, you may reasonably assume a maximum burn through range of approximately 50nm. You can see this using the Defence MFD.

Set the outside range scale to 100nm and mouse click the enemy radar range and enemy weapon range buttons on the left side of the MFD. The triangular fan extending from the nose of the enemy aircraft represents his approximate maximum radar detection range. To be on the safe side, we suggest you stay well clear of that fan during your manoeuvring. While it is true that our AIM-120 range is maximum when attacking head on (180 degrees aspect angle), that head on attack also extends the enemy's maximum missile launch range to a value approximately equal to the AIM-120 maximum. It is not necessary to attempt a head on shot and, in doing so, put yourself in danger. A better approach is to attack from the side or flank of the enemy. Do this, and you have an excellent chance of staying out of his radar search pattern. The effectiveness of this tactic can be further increased by using a flight member as a decoy to hold the enemy's attention while you manoeuvre unseen around to his flank. During your manoeuvring remember to minimise your RCS as described above. Sometimes, however, you cannot avoid detection. When this happens, what arethe indications?

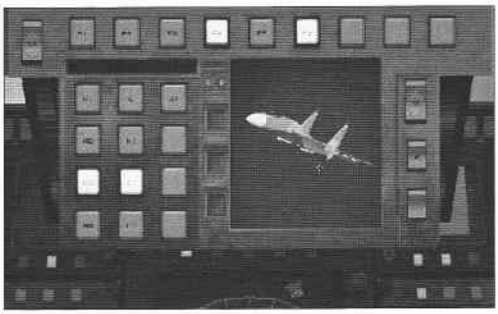


Figure 7- MAW Warning Lights

Your MAW provides the best indication that you have been detected. The MAW's red warning light is accompanied by an aural warning, either voice or tone, as determined by your selection.

Another indication that the target has detected you is noticing the target turning abruptly towards you. You can easily see this on the MFDs. By reducing the range scale on the MFDs, you will get a magnified picture of the tactical situation. This will make it easier to notice any target heading changes. On the HUD, you will see the heading change as the line extending from the nose of the target triangle suddenly turns and points at you. Once you get this detection warning, you have to make a decision on whether or not to continue with your attack.

These are your options:

1 If your own weapons launch is almost at hand, you may elect to press on with your attack. There are obviously trade offs in this situation. To have a reasonable probability of kill (PK) with your AIM-120, you need to be well inside 50nm. Taking a low PK shot is tantamount to wasting a missile and you are going to need every one you have. Therefore driving in to get a good PK missile shot may well prove fatal. The F-22 was designed to survive through stealth, it was not designed to battleship specifications to withstand multiple missile hits. For this reason, a 'no guts, no glory' do or die attitude may well result in the latter, to the detriment of the former, and is not in our best interests.

2 A second option is to command your wingmen to attack your target while you execute a descending hard turn and extend away to set up a re-attack. This may work well for you, but it is often fatal for your wingmen.

3 A better plan is to capitalise on our strengths.
These strengths are:

a. Fast acceleration to supersonic speed.

b. Low radar cross section.

c. Excellent off-board sensor information.

We should use these to best advantage. Other than continuing to drive into the heart of the enemy's launch envelope, a better plan may be to reposition ourselves for another attack. This tactic can be further enhanced through effective use of our wingmen. Later, in the Offensive Considerations section, these concepts will be discussed in depth.

4 If the tactical situation is such that none of these options is appropriate, then your best course of action is to order a retreat. In air combat terms, we call this an aborted attack.

5 **Aborting the Attack.** You can communicate this to your flight using the UHF radio and the call 'Skip It' or 'Abandon Mission'. These two terms refer to an orderly reversal of course. Your formation integrity should remain intact. Your wingmen are still in a position of support. Once the reason for the abort is no longer a factor, you can resume the attack, conditions permitting. If you do, do not forget to do a fence check.

If things get really desperate and you need to 'get out of Dodge,' then transmit the call 'Bugging Out.' A bug out is a wholesale retreat with every man for himself. Usually formation integrity and mutual support are lost, at least temporarily. Since a bug out is essentially an emergency procedure, turn in the shortest direction to evade the

enemy's radar. Determine this direction by using the MFDs to analyse his radar search pattern. To turn as tight as possible, slow quickly to about 400 knots, roll your lift vector below the horizon and make a maximum G pull to the desired heading. Once on that heading, accelerate while descending to low level. Your increased speed and the lower altitude will decrease the effective range of any enemy missiles fired at you, and terrain masking will help your escape. Once free of immediate danger, you can get divert assistance from AWACS using the UHF radio.

Part III Engagement tactics

As you close to firing range, the intercept phase of your attack is nearly over. All that is left is the trigger squeeze. At this point we would like to interject a major note of caution. This is not the time to get caught up in the excitement of the moment and let your guard down. The experienced pilot will take a few moments to review of his plan one last time for he knows once he fires his weapon, in all likelihood, the element of surprise will be lost. You too should take the time to make sure your attack plan is complete and on track. One way to accomplish this is to do another 'fence' check. These are the major questions you must ask yourself, anything less than a 'roger that!!' answer is unacceptable:

1. Do I have enough fuel to complete the attack and then disengage?
2. Do I have my flight in the desired formation?
3. Is the correct EMCON level selected? (Remember - this is critical. The AIM-120 will not fire in EMCON 1 and 2.)
4. Am I and the flight in the desired attack position?
5. Have I made the required radio calls to the flight?
6. Do I have the correct weapon and target selected?

If you have answered in the affirmative to all these questions, then there is only one more consideration to nail down before the flight enters the weapons firing stage. You must be completely clear in your mind about the anticipated outcome of the attack. Besides the happy aspect of turning your target into a flaming fireball, you must also be ready for him to do the unthinkable. He just might take your finely crafted game plan and tear it to shreds. The mark of a real pro is a plan that includes an answer to the question 'What if...?' If your enemy is not cooperating in your plan for his demise, and instead manages to turn the tables on you, a backup plan is nice to have. Be it an all out retreat, a reposition, or merely a change in target assignments, the point we want to make is that you need to have thought through all the possibilities. You must watch the attack as it develops, adjust your plan as conditions dictate, and, most importantly, remain in control. You must direct the fight, do not let the fight direct you.

Basic Offensive Considerations

In this section, attack chronology will be explained, followed by a discussion of specific offensive concepts. With this background in place, the discussion will then address each weapon system in detail.

The Attack Chronology

This section will take you through a typical offensive attack profile. In this attack, there are three weapons zones: the BVR AIM-120 launch, the Sidewinder follow-up attack, and, the ultimate in reaching out to touch someone, the gun attack. Let us begin as we complete the intercept portion and are approaching 50nm from the target. The following list of considerations are typical of the chronology of an attack. Later on, they will be covered in detail, as required.

1. Check your fuel state by calling up the Systems MFD or check the Nav HUD by cycling the 'H' key.
2. Use the radio to order your formation. Use the TAB key to abbreviate the keystrokes.
3. Select A2A HUD and double check the EMCON level.
4. Confirm your target heading has not changed. Use the Attack MFD to get a plan view of the enemy's course. Using this MFD, mouse click on the IRST button to both confirm target ID as well as get an excellent view of his nose position and bank angle. His turn towards you will be evident in the IRST view. Go back to the A2A HUD to confirm the target aspect angle is unchanged. If the triangle pointer is turning to point at the bottom of the HUD, he is turning into you.
5. Cross check your weapons status in the A2A HUD. Make sure you have the desired weapon selected as well as the desired release logic - single or ripple. If necessary, use the Systems MFD to change these settings.
6. Bring your weapon to bear on your target. Use the Attack MFD to note the range caret of your target relative to the range bar. The same data is displayed on the A2A HUD. Note the size of the steering circle on both the Attack MFD and A2A HUD. As it gets larger, your PK is increasing. Fly the target into the steering circle on the HUD. If the steering dot is displayed, turning towards it will fly it into the steering circle. This will add a lead angle that will further improve missile PK.
7. At the shoot cue fire your weapon. Fire when the steering circle is at maximum size. Fire when you hear the aural 'Shoot' command. Fire when you see the 'Shoot' command in the MFD or the HUD.

8 Use the firing technique known as 'Track - Shoot - Track' when firing an AIM-120. Continue to track the target after you fire the missile. This allows your on-board radar to provide last minute target position information to the missile. This technique improves the probability that the missile radar will acquire the target and, therefore, will improve the overall PK of the shot.

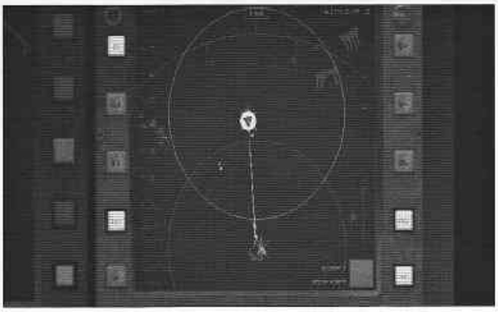


Figure 8 - Track-Shoot-Track

You may manoeuvre during this time, but not so much that you lose your radar 'lock.' Make sure the white 'lock-on' line between you and the target is maintained until the missile covers half the distance to the target as viewed on the Attack MFD. You will not be able to see this if you remain in the A2A HUD view. Once the missile has completed the required half distance, then you are free to cycle targets or break target lock. On the other hand, since Sidewinders and the gun are 'fire and forget' weapons, you may turn away from the target after firing.

9 After every weapon launch, do a 'Belly Check.' A 'belly check' is needed because, while you were concentrating on your attack, other enemy fighters may be targeting you. There are several ways to perform a 'belly check' in this simulation. You can select **F3** to see if you are targeted. You may select **SHIFT** and **F1** to get a six o'clock look. You can always select the Defence MFD and have a look around. The idea is to clear your six after a shot, never continue to follow your target after firing at him. While it may be cool to watch him turn into a fireball, your turn may be next if you are not careful.

10 Once you have cleared your six, reposition yourself for a re-attack or a disengagement. Tell your flight what you are doing.

Specific Concepts

1 **Airspeed Control.** You should be familiar with the energy diagrams in Chapter 4, 'Performance'. Two significant observations can be made using these plots: the F-22 ADF/TAW possesses a lower corner velocity (CV) than most adversary aircraft, and it can reach a faster top speed than most. The corner speed of the F-22 comes relatively early in its speed envelope.

For example, at sea level, CV is almost 300 knots, while max speed is about 1033 knots. The F-22 throttle response is excellent and one 'G' acceleration is rapid. Consequently, care must be taken in controlling airspeed. Throttle use as in other simulations will result in higher than expected speeds in the

F-22 EM Diagram

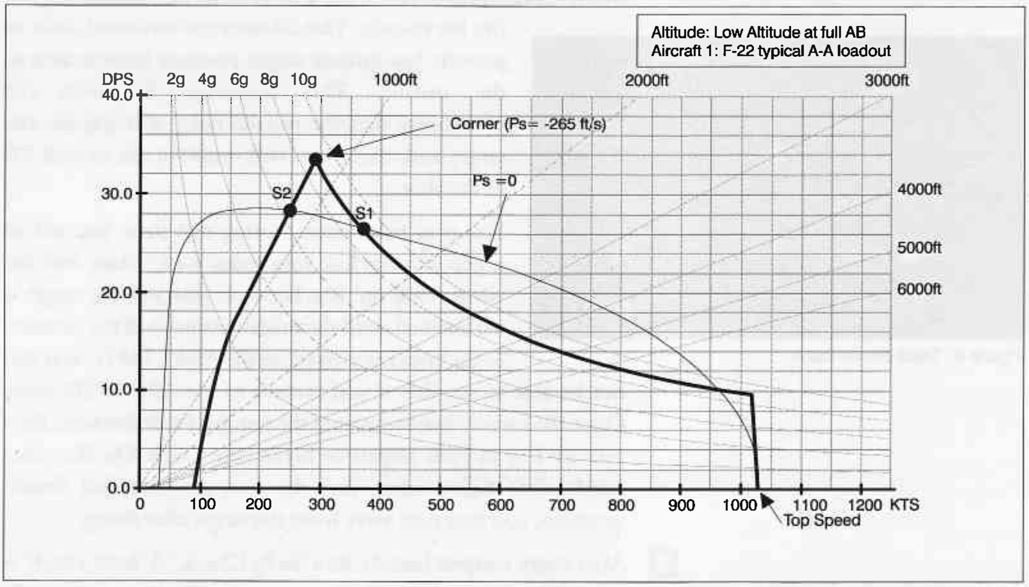


Figure 9 - Corner Velocity Diagram

F-22. This results from the high thrust-to-weight ratio that allows the F-22 to cruise at supersonic speeds without having to use maximum thrust. This 'supercruise' capability adds a tremendous punch to your offensive potential, but it can be a double-edged sword. As in any air combat simulation, as far as airspeed is concerned, you can get too much of a good thing. Supercruise at high speed is highly desired when attacking at long range, in repositioning, or when disengaging. But in a visual turning fight, you must watch your airspeed very carefully. Avoid the tendency to push the throttle up to max when a visual turning fight is begun. Too much speed and your turn rate and turn radius will be seriously degraded.

2 **Thrust Vectoring.** The F-22 ADF/TAW can move its engine nozzle up and down to alter its thrust line. This produces an accelerated pitch change and allows the aircraft to rapidly increase its angle of attack. The tilde key ~ is used to activate the thrust vectoring feature of F-22 ADF/TAW. Depressed and held, that key allows the F-22 to significantly increase its turn rate and decrease its turn radius for short periods of time. The downside of thrust vectoring is that it also results in a significant reduction of airspeed. It is best used to move the nose of the aircraft to achieve a weapons solution or to gain an angular advantage versus another aircraft. It should not be used as a defensive measure, for example, to aid in a missile break turn.

3 **UHF Radio Calls.** In air combat, pilots use the radio to do two things, describe what they see and direct another flight member to accomplish a manoeuvre. These are called descriptive and directive calls. The directive call takes precedence over the descriptive call. For example, if you were to see a bandit attacking your wingman, you would first tell him to 'break,' and then you would follow that call up with the reason why, such as 'bandit, your six, two miles, closing.' The radio calls in F-22 ADF/TAW are nearly all directive in nature. They are used to order your wingman to move to a particular formation or command him to perform a manoeuvre. These are the UHF radio calls and their meaning:

a. **'Engage My Target.'** You need to have a target in your shoot list to use this directive call. Your wingman will engage the first target in your shoot list.

b. **'Engage Bandit.'** Make this directive call when your wingman has called a contact on the enemy and you want him to engage that contact. If the wingman has not called a contact, he will not respond to this call.

c. **'Engage Hostile.'** This directive call will order your wingman to attack surface threats such as surface-to-air missile sites. Do not use it in an A2A engagement.

d. **'Engage Threat.'** After you are targeted by an enemy aircraft, you can use this directive call to order your wingman to attack that enemy.

e. **'Drag Left/Right.'** This directive call orders your wingman to act as a decoy to divert the enemy's attack away from you. You may then attack unseen as the enemy pursues your wingman.

f. **'Bracket Left/Right.'** This directive call orders your wingman to turn away from you and fly to the other side of the enemy formation. This tactic is called an 'offensive split' and allows you and your wingman to catch the enemy in a pincer.

g. **'Complete'.** This directive call orders your wingman to rejoin on you.

h. **'Break Left/Right.'** This directive call orders your wingman to perform a hard defensive turn. Ideally, you should order him to turn into the direction of the attack and away from your position. This will allow you to sandwich the enemy as he follows your wingman.

i. **'Break High/Low'.** This directive call is similar to the previous break call with the separation being taken in the vertical plane instead of the horizontal. Make this call when the enemy is

attacking from above or below your wingman's altitude. Order him to turn into the attack, if attacked from below, he should break low.

j. **'Bugging Out.'** This is a descriptive call made to inform your wingman that you must exit the engagement quickly and without regard to his position. There usually is a certain element of anxiety in the bug out call, it is often made before the enemy can regroup his forces and counter-attack you.

k. **'Skip It'.** This directive call tells your wingman to stop what he is doing and reform on you. It is typically used when no more gains can be made against an alerted enemy or one who is fleeing the fight.

l. **'Abandon Mission'.** This directive call is a blanket order for any reason that might call for you to end a mission, and is not usually associated with an enemy threatening you. If threatened, a bug out or break call is more appropriate.

4 **EMCON Techniques.** From an A2A point of view, there are only two practical EMCON choices: EMCON 1 or EMCON 5. In EMCON 1, you have the highest level of 'stealthiness', but you are also most vulnerable to enemy attack and you are limited to Sidewinder and gun. Use EMCON 1 with considerable caution in an engagement. While there may be times when its use is advisable, you must be aware that its disadvantages can easily override its advantages.

Of particular significance is the relationship of the radar track feature to AIM-120 probability of kill. During the first half of the missile's flight, it can receive guidance information from your aircraft. This updated information raises the PK of the missile especially in those situations where the target has turned after your missile launch. Radar tracking information will cue the missile to fly towards the new target position. Then, when the AIM-120's own radar comes alive and begins to search for the target, it will more easily locate and track the target. If you select EMCON 1 or 2 you will lose your radar tracking capability. If the target then turns, the AIM-120 has a degraded ability to locate the target in its new position. Earlier, we referred to this in discussing the 'track-shoot-track' technique.

Because of the lowered AIM-120 PK and other degraded defensive systems in EMCON 1, we recommend that, once you have committed yourself to weapons launch, you remain in EMCON 3 or higher.

5 **Use of Shoot Lists.** The shoot list concept is one of several that give F-22 ADF/TAW that strategic feel lacking in other air

combat flight simulations. You should be very clear in your understanding of all aspects of the shoot list since the list determines the order of firing of the selected weapon. Nothing can be more frustrating than to trying to attack one target when the weapons release logic in the shoot list has another enemy aircraft targeted.

The preferred method of building a shoot is 'automatic.' You command this by pressing the T key or mouse clicking the RETURN SHOOT LIST TO AUTO button on the Attack MFD. The avionics then uses the number of weapons remaining and target bearing, speed, and type to build the list. The MFDs display these targets by putting a circle around them, and the HUD displays them as triangles with solid lines instead of dashes. You can also manually build or modify the shoot list by mouse clicking the new target on the Attack or Situation MFDs. When you select this new target, it becomes the first target on the shoot list, and the original targets move down the list one position.

You can add an enemy flight of four aircraft to the shoot list in this manner: first, place that target into the shoot list and then press F2 to bring up the player-to-target padlock view. Then press the S key three times to add the other three bandits to the shoot list.

6 **Target Cycling.** Target cycling is the process by which weapons are assigned to specific targets in the shoot list. This may be done automatically or manually. Manual cycling is the normal mode of operation. Manual cycling is commanded by pressing the C key to step through the targets in the shoot list. If you want to reverse the cycle order, press the X key to back up the selection process. Automatic cycling is selected by clicking the Attack MFD 'CYCLE TARGETS AUTOMATICALLY' button. The important thing to remember is that in manual mode, you must press the C key to move to the next target in the shoot list after firing a shot. If you do not, then you will fire at the original target again and most likely waste a valuable weapon in the process. In auto mode, the shoot list will be advanced as each weapon is fired.

7 **Target Sharing.** If you have a wingman, you can command him to attack a specific target by one of two methods that we will refer to as the padlock method and the MFD method. The padlock method is particularly suited for a visual engagement when you come under attack from an unseen enemy or when you have multiple bandits and you want to assign some of them to your wingman. The MFD method is well suited for BVR manoeuvring when time is not as critical a factor. To assign

targets using the padlock method, press the **F2** or **F3** key to bring up the respective target or threat in the helmet mounted display. Then press the **M** key to assign that target or threat to your wingman. In this manner, you can command your wingman to 'clear your tail' of any threats as you focus on your own attack. Using the MFD method will require you to click on the enemy flight that you want to assign to your wingman. You may also use the **C** key to cycle your target. That puts that enemy first in your shoot list, then use the directive radio call 'Attack My Target' to command your wingman to attack that target. Once your wingman acknowledges that command, you are free to reconfigure your shoot list as the situation requires.

8 **Weapon Release Sequencing.** When faced with multiple targets, you can reduce your workload by automating the sequence in which your weapons are fired. We usually think of firing a single weapon with each trigger squeeze, but F-22 ADF/TAW allows us to fire multiple weapons with a single trigger squeeze. This is known as firing in ripple. Think of ripple as 'one after the other.' The significance of this weapon release mode is that it allows you to quickly release weapons at multiple targets as determined by your shoot list. For example, if you ripple four missiles, they will fire in the interval selected and be individually targeted according to the shoot list. A good example of this tactic in action is the attack known as the 'Grinder.' In the Grinder attack, you will individually assign an enemy four ship to your shoot list using thetechniques described above. Then, when you pull the trigger, four missiles will ripple fire, and each will be aimed at its own target. You should configure the Systems MFD for ripple fire as part of your fence check. Remember, salvo fire does not apply to air to-air missiles.

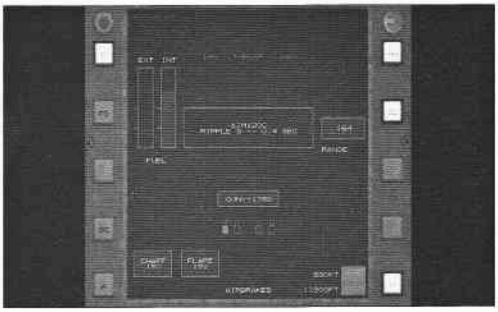


Figure 10-Ripple Release Panel

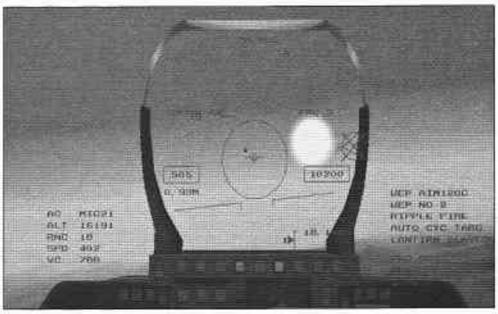


Figure 11-Ripple Release HUD view

9 **Player Views.** 'Kill the bandit...live to fight again another day.' A simple proposition to make, but not so simple in execution. 'Lose sight...lose fight.' Many a fighter pilot has gone to the big hangar in the sky after having violated that bit of wisdom. In F-22 ADF/TAW, you will use its superior avionics to enter the engagement with many advantages, do not throw it all away by losing the tally ho. Fortunately, you have an equally superior set of player views to help you ensure that possibility never happens.

F-22 ADF/TAW is configured with an unusually wide range of player views. Not all of these views were intended for use in A2A engagements. Some of the views have been included strictly for their entertainment value, they provide a visually exciting and panoramic look at aerial warfare that comes closer to being a documentary than an air combat flight simulation.

For our purposes, however, three sets of player views provide us with an 'inside the cockpit' as well as an external perspective that are unsurpassed in their replication of the visual and visceral feel of air combat. These views are grouped into the virtual cockpit views, the current weapon target padlock views, and the current threat padlock views.

a. **The Virtual Cockpit.** The F1 key is used to select the most traditional of air combat views, the through-the-HUD view of that airspace directly in front of your aircraft. The HUD in the A2A mode contains nearly all the information you will need to initiate and terminate the final stage of your attack, weapons employment. Known in the past as the 'gunsight' or the 'combining glass,' the HUD functions minimally as nothing other than aiming device. But of course, it is much more than that. The F-22 HUD provides you with comprehensive information on your flight conditions, your weapons status, and the first target in the shoot list. The MFDs can be brought into view and are functional. Use the Page Up/Down keys to change the MFD range scales. You may also cycle your targets by using the C key, this allows you an easy way of checking the relative ranges of multiple bandits and get an update on potential threats in your immediate vicinity.

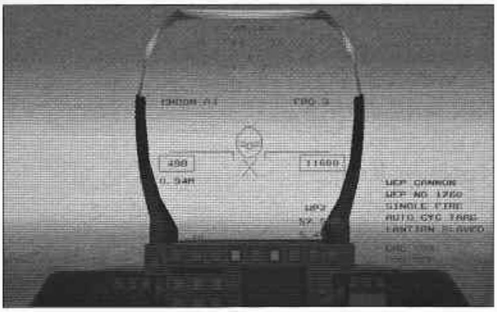


Figure 12 - Virtual Cockpit HUD

Besides the typical forward view in which the HUD takes centre stage and is the primary focus of attention, the F1 virtual cockpit view can be expanded by pressing the K key to widen the overall scope of the view. The effect is as if the pilot moved his seat farther back in the cockpit. This expanded view in addition to showing a wider outside view, also includes the MFDs that again are functional but can be difficult to read.

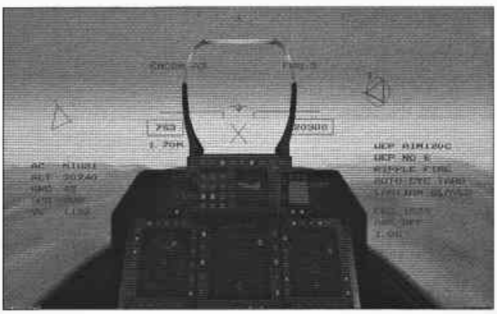


Figure 13 - HUD Wide View

These two views can be slewed using the hat switch on your flight stick. This is particularly useful in keeping in sight a target that has just moved out of the HUD field of view. You can slew the view approximately 180 degrees horizontally both right and left all the way back to your six o'clock. You may also slew the view up to nearly vertical and down to

easily look at the Systems MFD. Moving the hat switch in the opposite direction will bring the view back to normal. You can also quickly return to a 12 o'clock focus by pressing the F1 key. Pressing the F1 key again will remove the HUD frame and cockpit glare shield and replace them with an unimpeded 12 o'clock view with all of the HUD information as before. Small but functional MFDs are included at the bottom of the view. This view is not slewable using the hat switch.

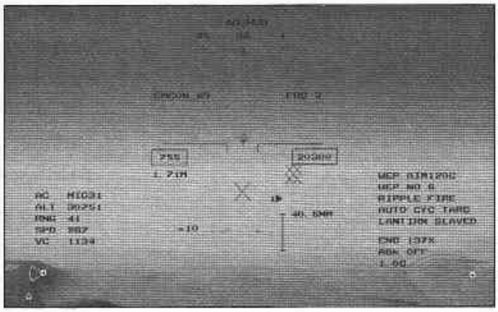


Figure 14 - HUD Without Cockpit Frame

The F1 key provides one more useful view. Press the shift key in conjunction with F1 to get a good view of your six o'clock area. This view is not slewable.

b. The Target Padlock. Press the F2 key to select a padlock view of the target that is currently first in your shoot list. This is a significant point to remember. If you cycle your target selection, this view will instantly change to the new current target, this can be very disorienting if you are unprepared for the screen shift.

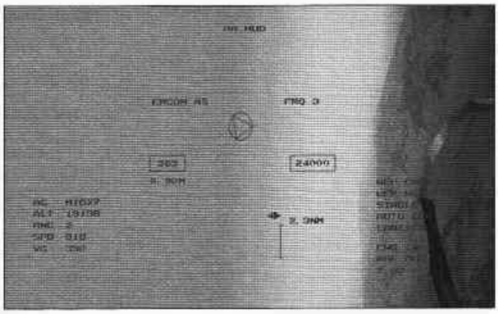


Figure 15 - HUD Padlock View

There are three views in the target padlock. Your first press of the F2 key brings up the HMD (Helmet Mounted Display).

The HMD replicates what it would look like if you were to look right at the current target. This view contains the symbology found on the HUD. This HMD view stays 'padlocked' on to the target regardless of where your aircraft is actually pointed. If the target is in front of your aircraft, then the view will include all or part of the HUD, depending on how close the target is to your 12 o'clock. An example will help explain this padlock feature. Imagine your target coming straight at you from your 12 o'clock, then flying past your right wing and eventually disappearing from view at your six o'clock. As the target approaches your nose, the target padlock view will initially include the HUD. The target is the triangle with the circle around it. As the target flys past your right side, the HUD will move left and out of view as the HMD pans around to follow the target. Your aft fuselage will be visible as the target continues on to your six o'clock .

An important point regarding the target triangle needs to be made. The triangle pointer shows target aspect angle. When F-22 ADF was first released, the pointer was a heading reference. This was changed with the release of the F-22 ADF patch. Since the patch, F-22 ADF and F-22 TAW use the pointer as an aspect angle reference.

An easy way of interpreting aspect angle is to think of it as how the target looks to you as you are presently looking at it. This removes your heading relative to the bandit as a factor in interpreting target position. In this manner, you interpret aspect angle from the target triangle in the same manner regardless of whether you are looking through your HUD or over your shoulder. The 'up' or 12 o'clock position of the target triangle means the target is pointing away from you. This is zero degrees aspect. The 'down' or 6 o'clock position means the target is pointing directly at you. This is 180 degrees aspect. If the target triangle pointer is pointing anywhere either side of the 12/6 o'clock line, then you are looking at that side of the target. For example, a 3 o'clock pointer means you are looking at the target's right side. A 10:30 o'clock pointer means the target is going away from you and you are looking at it's rear left quarter.heading relative to your aircraft heading. Finally, a pointer at the 4:30 o'clock position is a 135 right aspect, you are looking at the target's right front quarter. The direction that the HMD is looking has no effect on the direction of the target triangle aspect pointer.

Aspect angle is referred to in number of degrees from zero to 180, and will include the direction, right or left, if the aspect is not exactly 180 or zero. A 12 o'clock pointer is zero degrees... a 6 o'clock pointer is 180 degrees. In the previous example, the 3 o'clock pointer indicates a 90 right aspect, and the 10:30 pointer indicates a 45 left aspect. Remember, the direction your HMD is looking is irrelevant.

To sum it up, if the pointer is 'below' the 3 o'clock/9 o'clock line, then the target is pointing in your direction and should be considered a threat. Conversely, if the pointer is above the 3/9 o'clock line, the target is heading away from you and is not an immediate threat.

Finally, to help you stay oriented when the HUD is out of view, the padlock view includes 'vee' shaped translucent arrows, called 'canopy markers.' An explanation of these markers and their use will come later in this section.

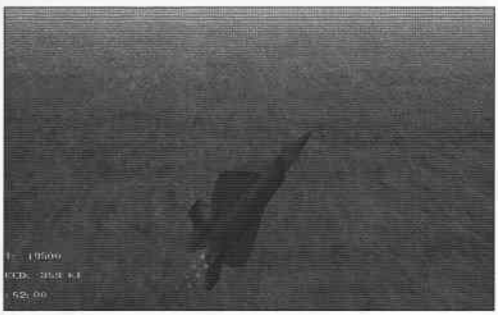


Figure 16 - External Padlock view

A second press of the **F2** key will switch the view to an external 'player-to-target' view of your aircraft. The perspective this view gives is one of looking through your F-22 at the target.

The target aircraft will be visible in the background only when in visual range, typically, this range has a maximum of about three miles. If the target moves outside this maximum range, it will disappear and nothing in the view will cue you to its location. Should this occur, you will have to change the view

back to padlock by pressing the F2 key again. A more detailed discussion of this view will follow later.

A third option is available in target padlock. Press the SHIFT and F2 keys to change to a second external view, the 'target-to-player' view. This view follows the currently targeted enemy, and as long as your aircraft is in visual range, it will be visible in the background. There is little relevance of this view to the tactical manoeuvring arena, it is nice to look at, but is of little value.

c. **The Threat Padlock View.** Press the F2 key to select a padlock view of an enemy missile targeted on your aircraft or the enemy aircraft that is the most immediate threat to you if no missile has yet been launched at you. This view functions only when you are being fired upon or threatened. As with the target padlock, there are three types of views associated with the threat padlock.

The first of these is the HMD view of the incoming threat. If the threat object is beyond visual range, then all you will see will be the threat triangle. Again, as in the target triangle discussed above, the triangle pointer is an aspect angle reference. Another note is in order, the enemy aircraft data in the HMD is data for the first target in your shoot list. Therefore, unless the threat is also your target, the data in the F3 padlock is not related to the threat. If this is the case, then you cannot use this range information to plan your defensive reaction since it is the range to your target, not the range to your threat.

A second press of the F3 key will select the 'player-to-threat' external view, and pressing the shift and F3 combination will bring up the 'threat-to-player' external view.

The threat padlock and external views will automatically revert to the F1 forward view whenever the threat missile or aircraft no longer poses a danger.

One other caution to keep in mind using the F2 and F3 external views, you cannot select a MFD display until you first go back to the padlock view.

d. **How To Use The Padlock Canopy Markers.** The use of the padlock view becomes difficult and disorienting anytime the target or threat moves sufficiently far enough away from the nose of your aircraft such that the HUD is no longer in view. With the HUD out of sight, you lose touch of where your aircraft is heading. You lose the ability to connect in your mind the picture of

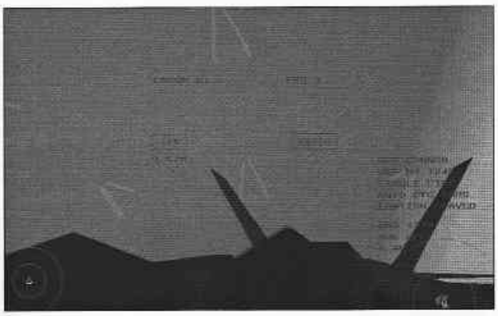


Figure 17-Canopy Markers Looking Rearward

the HMD padlock display with the attitude of your aircraft. When you pull back or roll with the flight stick, it is very difficult to 'see' what your aircraft is doing because there are few cues to tell you what your orientation or flight attitude is. Simply pulling back on the flight stick and hoping the HUD will eventually come back into view is poor technique and may not work at all. You may end up spiraling yourself into the ground without ever bringing the HUD back into sight. There has to be a better way and there is. Visual cues called 'canopy markers' are projected on to the padlock view and look like translucent 'vee' shaped arrows.

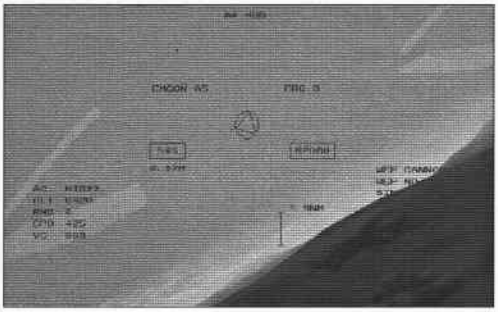


Figure 18 - Side view of Canopy Markers

The canopy markers originate at the rear of the canopy and are arranged as three rows of 'vee' shaped arrows pointing towards the nose of your aircraft. Think of them as a centerline row and two side rows, one on each side of the centerline row. As the two side rows move away from the rear of the canopy, the distance between them and the centerline row widens. Each leg of the centerline row is of equal width, while the side rows have one thick leg and one thin leg. The centerline row can be thought of as being an imaginary line painted exactly along the top of your canopy, extending from the rear to front. The two side rows can be imagined as lines on the canopy about halfway between the canopy rail and the top of the canopy, one on each side, originating again at the rear of the canopy and extending to the front. The thick leg of the side row is towards the canopy rail, and the thin leg is towards the centerline row.

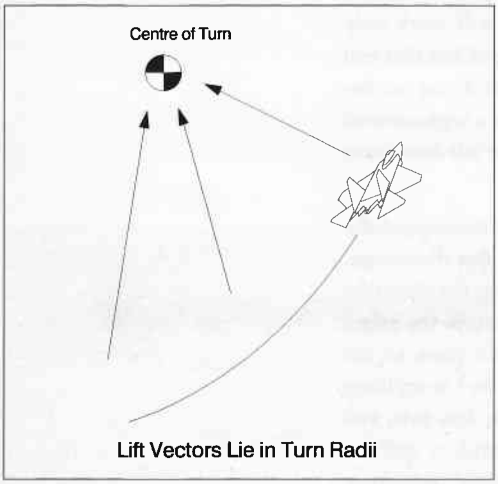


Figure 19

This is how you visualise where you are looking using the canopy markers. Remember, they are used when neither the HUD nor any other part of the aircraft provide sufficient reference cues to orient your attitude. Also remember that the padlock view represents a HMD view of the target or threat, in other words, your eyes are locked on to the target or threat. The canopy markers are intended to provide a way for you to fly your nose back to the target or threat. Therefore, when you use the padlock view, you are looking at the target or threat through some part of the canopy. The rows of arrows tell you what part of the canopy you are looking through. Use the direction the arrows are pointing to determine which way your nose is pointing and which side of the canopy you are looking out of. If you see only a row of arrows with equal sized legs, then you are looking out the top area of the canopy.

With that clear in our minds, let us shift gears for a moment and think about how an aircraft is manoeuvred. You are, by now familiar with the concept of the lift vector (see Chapter 4, 'Performance'). It is that imaginary line projected out the top of the canopy that represents the flight vector of the aircraft.

We aim the lift vector at where we want to go and then pull back pressure to point the nose in that direction. We aim the lift vector by rolling the aircraft with the ailerons until we have the canopy, (the lift vector), pointed in the desired direction, and then we pull back pressure to point the nose. Roll to aim - pull to point.

Now, back to our canopy markers. Let us imagine ourselves using the padlock view. We are looking at the target triangle, and, because we cannot see the HUD or any part of the aircraft, we know we are looking out of some part of the canopy. Our objective is to point our nose at the target. To do that we need to get our lift vector on the target so we can pull our nose to it. Here is how we do it. Roll smoothly without any back pressure until you get the centerline arrows superimposed over the target or target triangle. If you initially see either side row, then roll towards the thick leg to bring the centerline row over the target. Now pull back on the stick until the HUD comes into view. Then you can switch views back to F1 or continue in F2 or F3 to press your attack.

This technique is known as lift vectoring. When flown as described above, it is, in its most basic form, a brute force method of bringing the target to your nose. Some have referred to this technique as the 'G for brains' approach, and that is a pretty fair description. In fact, this technique will work only when you have a turn rate advantage over the target, but that will be the case most of the time in F-22, particularly if you use the thrust vector feature to good advantage. It is not a sophisticated way to manoeuvre your aircraft, but it will get the job done most of the time.

One other point should be made. We have not mentioned the relationship of the horizon to our flight path in this discussion. We need to do that. The canopy markers point in the direction of your nose. Before you begin to pull your nose to the target triangle, you want to look 'through' the arrow rows to the background. What do you see? All ground? All sky? Something in between? If your altitude or airspeed is on the low side, you may not want to 'Split-S' into the dirt on one hand, or stall out on the other by blindly following the 'G for brains' technique. Instead, you will need to use the canopy markers to manoeuvre out of the target's plane of motion.

10 The Canopy Markers And Three Dimensional Manoeuvring. As your proficiency and comfort level increase with your use of the canopy markers, you will want to consider a more sophisticated use of them. The 'G for brains' technique is essentially an in-plane, pure pursuit method of manoeuvring relative to your target. As we are sure you understand, sometimes it is quicker and more effective to manoeuvre out of the target's plane of motion. We call this 'split-plane' or three dimensional manoeuvring. Accomplishing this using the canopy markers is challenging, but entirely possible. Here is the essence of what you want to do. First, let us state our objective. We want to point our nose away from the target, we are trying to get some turning room away from the target's plane of motion.

The canopy markers play an important part in building a three dimensional picture of the relationship between yourself and the target. The canopy markers are going to provide you with two critical pieces of information. First, they will tell you which way your nose is pointing. Second, the markers will tell you which side of the canopy you are looking out of. Use the thick leg to determine this. Let us imagine yourself looking at a padlock picture that shows your nose is pointing to your right and that you are looking out the left side of the canopy at the target. Now, let us look at the target triangle, more specifically, look at the pointer direction.

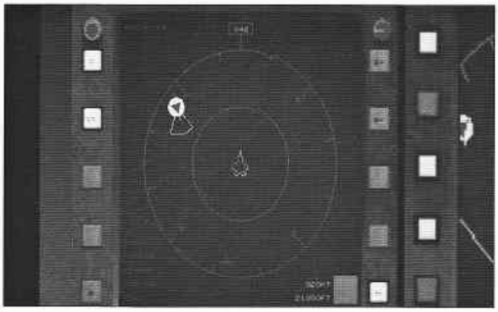


Figure 20a

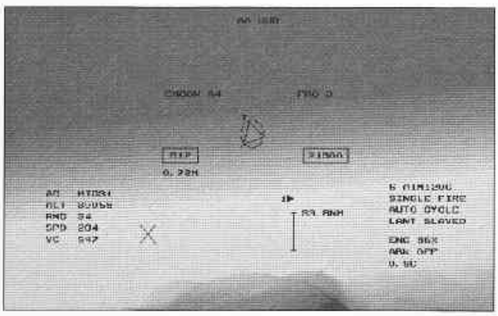


Figure 20b

Remember, the pointer shows you the target's aspect relative to your position. It is an indication of the direction the target is heading as seen from your HMD line of sight. Here are some general rules for interpreting target aspect when the HMD view is looking out of the side of the canopy (Figures 20a and 20b present the MFD and HMD view of each situation).

a. If target aspect is between 180 degrees and 90 degrees and the target aspect 'side' is the same as the side of your canopy view, then the target is pointing behind your aircraft. The target nose is in lag pursuit. For example, picture your HMD looking out the left side of the canopy with the target pointer at 7:30 o'clock (135 Left aspect). Consider this target a threat.

b. Conversely, if the target aspect 'side' is opposite of your canopy side, and the target aspect is again between 180 and 90 degrees,

the target is pointing in front of you. His nose is in lead pursuit. In this example, picture your HMD again looking left with the target pointer at 4:30 o'clock (135 Right aspect). This target is definitely a threat. When you assess this threat, look at his range. If his range is inside 3 miles, then you should consider him a potential gun threat.

c. If the target aspect is exactly 180 degrees, he is in pure pursuit and again is a threat. 180 degrees of aspect is when the pointer is at six o'clock.

d. If the target aspect is less than 90 degrees, he is heading away from you. At this point, he is not a threat.

Here is another way to explain this. The pointer shows you the target's aspect angle, if you see a triangle with the pointer pointed to the right, then you are looking at the right side of the target. Do not confuse this with angle off. To compute the target's angle off, you must associate the position of the HMD relative to you with the direction that the target pointer is pointing. An explanation might help.

Let us imagine we are heading 360 degrees. If you are looking through the HUD at a target triangle whose pointer is pointing to the 3 o'clock position, you have a 90 Right aspect. You are looking at the right side of the target and that target's heading is approximately 090 degrees. Now, let us reverse the situation. You are looking to your six o'clock. Your aircraft is still heading 360. The target triangle pointer is still pointing to the right. The target aspect is still 90 Right, therefore you are looking rearward at the target's right side. The target's heading is now approximately 270 degrees.

If you have this clear in your mind, then we can finish off our discussion of how to manoeuvre out of plane using the padlock view. While the idea is relatively simple in

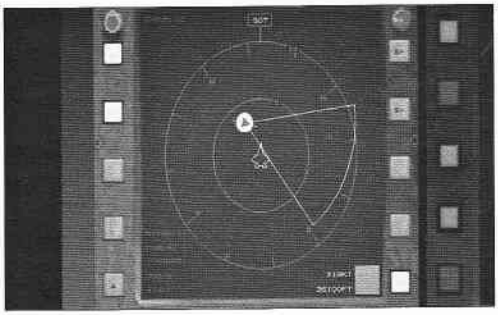


Figure 21a - MFD view of Right 135 aspect target

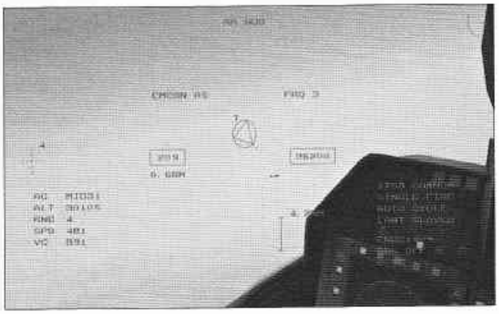


Figure 21b - HMD view of Right 135 aspect target

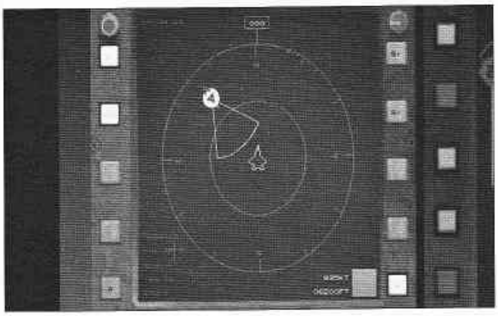


Figure 22a - MFD view of 180 aspect target

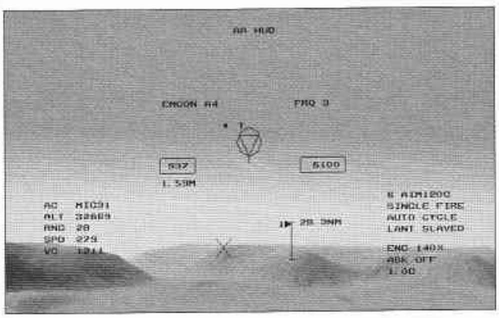


Figure 22b - HMD view of 180 aspect target

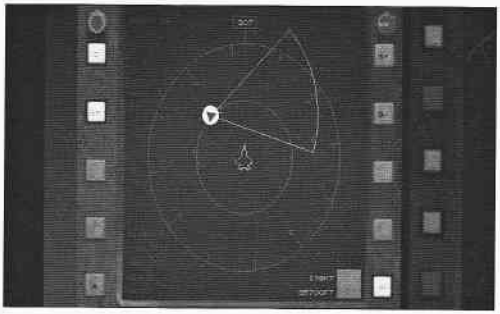


Figure 23a - MFD view of aspect less than 90 degrees

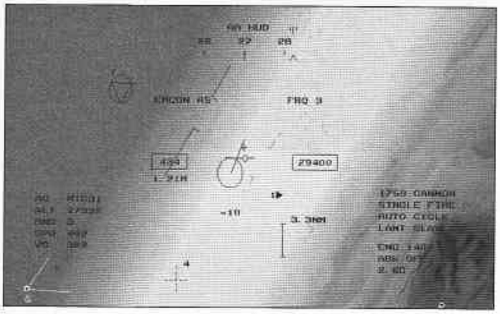


Figure 23b - HMD view of aspect less than 90 degrees

concept, it is very difficult to perfect in execution. You must take the padlock picture and analyse it for several important items. These are your nose position, target aspect, and the position of the horizon. You then roll to point the centerline canopy marker (your lift vector) in a direction that is dependent upon your aspect angle. Your interpretation of target aspect angle will determine which way this is. We can make the following generalisations about lift vector orientation relative to aspect angle:

e. If you determine that the target is in lag pursuit, then an in-plane turn into the direction of the target will decrease his available turning room, increase his angle off, and improve your chances of forcing a flight path overshoot. Overlay the target's plane of motion with your centerline canopy marker and pull.

f. If you determine that the target is in lead pursuit, then turn into the target. Check his range. If his range is less than three miles, consider him a gun threat and manoeuvre out of his plane of motion. If you can, make this out-of-plane move to the high six o'clock of the target relative to the horizon. This will get you out of his gun line and slow your velocity relative to his. Do this by rolling to put the target triangle between the canopy rail and the thick leg of the side canopy marker. The centerline marker, your lift vector, will then be 'above' the target, verifying that your flight path is out of the target plane of motion.

g. If faced with a 180 degree aspect pure pursuit situation, make an in-plane hard turn into the target by placing the centerline marker over the target triangle. Turn as hard as possible to force the target to your nose and take away his turning room. Once the target is in your front quarter, then apply the general rules in (e) or (f) above.

h. For aspect situations where the target is heading away from you, roll to place the centerline marker over the target and turn hard in-plane to bring your nose to him as quickly as possible. As the target nears your nose, analyse your closure and point your nose into lead or lag pursuit as necessary.

Now if this explanation has left you somewhat confused or hesitant, do not feel alone. Split plane manoeuvring using padlock is for only the most experienced pilots. 'Is there another way?', you may ask. Fortunately, there is. Please read on.

11 Split Plane Manoeuvring Using The External View. The second press of the F2 or F3 key selects the 'player-to-target' or 'player-to-threat' external view. This perspective on the action allows you to see your aircraft in the foreground and the target or threat in the background, assuming that target or threat is within visual range.

You control your aircraft much as someone would fly a radio controlled model airplane. The writers of this guide are in agreement that this external perspective of a visual engagement is the most intuitive view of a three dimensional relationship between two aircraft. When you see both your F-22 and your target or threat at the same time, you are able to immediately recognise your angle off and aspect. There is no need for artificial cues such as canopy markers or heading pointers to create an awareness of the spatial relationship between the two aircraft. We recommend that you give serious consideration to using this view technique to help solve whatever manoeuvring problem you may be faced with. We say 'help solve' because no single view will be sufficient in most situations. Instead, you will need to switch between HUD and HMD views and between internal and external perspectives to solve your three dimensional problem.

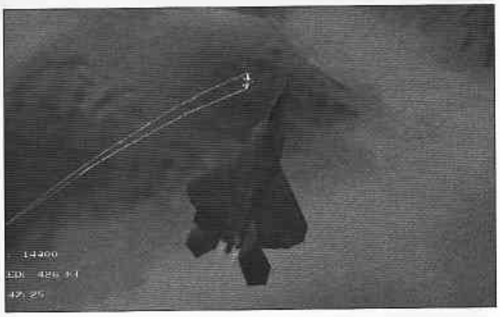


Figure 24 - External Padlock

The three dimensional problem presents you with two manoeuvres

a. Use the forward looking views, those which include the HUD or HMD, to employ your weapon.

b. Use the padlock views to reduce aspect and angle off whenever the target or threat is outside of visual range.

c. Use the 'player-to-target/threat' external view to control fuselage alignment and solve the three dimensional problem whenever the target or threat is in visual range.

Be prepared to use a combination of all three views in any engagement. Each has its strengths and weaknesses. Proficiency in using all three will make you a formidable adversary.

12 Merge Considerations. 'To merge or not to merge, that is the question.' No, Shakespeare did not say that, but you will every time you go head long into the enemy. The F-22 has been designed to kill at long range without needing to engage in close in dogfighting. But the history of air combat has taught the same lesson again and again, 'Never say never!' So it will be with the F-22. Regardless of the circumstances, inevitably, you will have to join with the enemy, eyeball to eyeball. Fortunately, our F-22

is not following in the examples set in past conflicts. It is not the Wildcat or Hurricane versus the Zero, or the F-4 versus the MiG-21. It is not even the F-16 versus the MiG-29. It is at worst at least equal to its best adversary, and at best, better by far than most. Therefore, remove any doubt about the manoeuvrability of the F-22 being a factor in your decision to continue your attack into the visual arena.

There are, however, some very significant considerations that you must never lose sight of when you weigh the pros and cons of continuing your attack into the merge. And, as you might suspect, there are no easy answers. Expect to be outnumbered. Expect that the PK of your weapons may not be 100 percent. But never expect to be out-matched. Your manoeuvrability, your defensive counter-measures, your automated attack avionics, and, most importantly, how you use these assets, will make it more than an even fight.

13 **ACMI.** The training value of the Air Combat Manoeuvres Instrumentation (ACMI) cannot be over-stated. Playback of an ACMI recording of an engagement will provide you the same lessons learned that an ACMI does in real life. You initiate ACMI recording any time during a mission by pressing the ALT and R keys. Pressing them a second time ends the recording.

AIM-120 and Sidewinder Tactics.

Specific information on the missiles can be found in Chapter 5, 'A2A Weapons'. The following are some employment considerations that you may find useful.

1 **Weapon Type and Aircraft Load Out.** Refer to the Systems MFD for a graphic on which type of missile is loaded, where it is loaded, and how many are loaded. Use this MFD to designate single or ripple fire, numbers of missiles to be fired, and the interval between firing. Please note that A2A missiles cannot be fired in salvo.

2 **Maximum Launch Range.** Maximum launch range is a function of the missile's ability to fly the distance to the target. This range is based on the distance the missile can cover during its effective time of flight. Both the target's speed and your speed, your closure, will have a direct effect on this distance. The higher this closure, the more distance the missile can cover during its time of flight. Consequently, head on attacks with high closure rates result in the longest ranges, and tail chases produce the shortest ranges.

3 Missile Steering Circle and Steering Dot Information. This circle is displayed on the HUD as well as the Attack MFD. The size of the circle is a direct indication of your PK. PK will be greatest when the circle is at maximum size. Be sure to be in F1 with A-A HUD selected. Fly your nose to the target. If possible, manoeuvre to put the steering dot in the middle of the steering circle...this gives the missile a lead angle on a target that is crossing your nose.

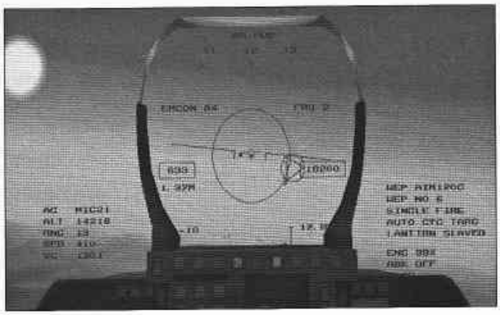


Figure 25

4 Shoot Cues. Wait for your aural or visual shoot cue before firing. The HUD and Attack MFD will show the word 'Shoot', and you will hear the aural command, 'Shoot, Shoot.' This cue will come as PK approaches its maximum. You may shoot earlier but with a less than optimum chance of scoring a hit. Our advice is fly your nose into the steering circle. Centre the steering dot and wait for the shoot call, do not waste a missile. Listen for the Sidewinder 'growl' to accompany the shoot cue and look for the Sidewinder lock on box to bracket the target.

5 Tips On Maximising PK. Do not fire out of range. If possible, wait for the shoot cue. Fly the steering circle and dot on the HUD for best lead angle. After firing the AIM-120, hold your heading steady until the missile has flown one half the distance to the target. Use the Attack MFD to determine maximum PK. At the half way point, your avionics will give the missile one last update on target bearing and altitude. This allows the AIM-120's radar seeker to have the best possible chance of acquiring and tracking the target. High closure speed will minimise both missile's flight time and, in the process, minimise the target's ability to manoeuvre out of the way.

6 Switchology. If a missile is carried internally, you must open the missile doors first by pressing the space bar or trigger. Then fire the missile with a trigger squeeze or another press of the space bar. Use the fence check to make sure you know where your missiles are loaded, you do not want to shoot a weapon out of range because you thought you were only opening the missile doors. If the Sidewinder lock on box is still moving about in its search pattern, and you know you are in range, you have probably forgotten to open the missile doors for an internally carried IR missile.

Gun Tactics.

Of all the weapons carried on a fighter, the gun is the oldest and the most difficult to get a kill with. Nothing has changed since World War One, nothing. You and the Red Baron still have the same problem to solve. He had to get in range and he had to get into his target's plane of motion. So do you. You have some advantages. Your 20mm cannon has a higher firing rate, is more destructive, and has a longer range. He had a 'ring and bead' gunsight, and he had to apply his own 'windage' and lead angle. You have a lead computing gunsight, which under ideal conditions will do a pretty good job of figuring some of that out for you. Please note the words used were, 'ideal,' 'pretty good,' and 'some.' That is because there is no such thing as a 'death dot' gunsight. Some late model gunsights come fairly close to having a 'death dot' capability under perfect conditions. While the F-22 sight is not one of those, it can be a very effective aiming system when used properly. To learn how, let us look at how our sight performs.

1 **The Predictor or Disturbed Reticle Gunsight.** The F-22 ADF/TAW LCOSS (Lead Computing Optical Sight System) attempts to show you bullet position in space as a function of Time Of Flight (TOF). We will use the word 'bullet' (we know the 20mm projectile should be called a 'round'), but we like the word 'bullet' better. Here is how the LCOSS works.

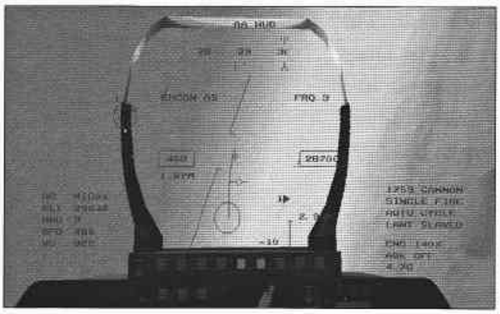


Figure 26

First, the gunsight computer gets a gyroscopic input that tells it where your flight path is. This is your plane of motion. You need to maintain a fairly steady attitude and G load for the computer to do its work correctly. As your nose moves along its plane of motion, think of it drawing a line in the sky. That line is a projection of your plane of motion. That line will be only as straight as your ability to fly a steady attitude and G load. When the gun is fired, the bullets start out in this line and then fall below it due to gravity drop. How far these bullets fall below that line is strictly a function of time. Therefore, our first point of emphasis is that your bullet path follows your flight path, at least initially.

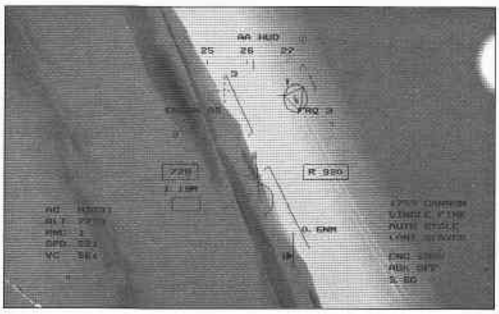


Figure 27

The second point to understand is that the target's speed and angle crossing your nose results in it covering a lot of airspace during the bullet's TOF. This requires us to lead the target by aiming in front of it in its plane of motion. We also need to add a gravity drop correction. The result is a lead angle corrected for gravity that is based on a given TOF.

This lead angle is shown in the A2A HUD as the distance from the circular pipper to the fixed gun cross symbol. The gun cross is that small + in the middle of the HUD. It is also known as the centerline marker. A movable line known as the 'snake' connects the pipper and the gun cross. The gun cross + is a good representation where the bullets appear on the HUD right after they are fired. Let us put our F-22 into a turn and then go back to our gyroscope concept in the first paragraph. As we pull G in the turn, the gyroscope senses this g. It sends this data to the LCOSS computer which uses it to compute your plane of motion. The LCOSS then projects a line on the HUD that shows you a depiction of your plane of motion. This line originates at the gun cross. This line is the same line we call 'the snake.' The length and direction of the 'snake' are determined by how hard we pull on the flight stick.

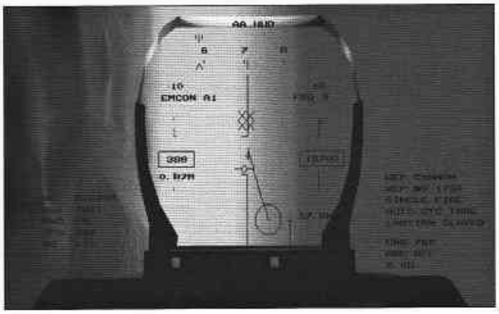


Figure 28

Now, let us bring the pipper into our discussion. The pipper is actually the little dot in the centre of the range articulated circle, but the circle has been called the 'pipper' for years, and we will stick with tradition. The pipper is at the end of the snake. The articulated circle shows range to target in tenths of a mile. The circle is completely round outside of one mile. As range decreases below one mile, the circle begins to disappear in a counter-clockwise direction, starting at the 12 o'clock position. The edge of the gap in the circle indicates target range. If the gap is at 9 o'clock, then the range is 0.9 mile, at 6 o'clock, the range is 0.6 mile, and so forth. Under most conditions, for best PK, do not open fire outside the 5 o'clock position.

There is one more contributor to our LCOSS solution, and that is the range to the target. The radar measures the distance and angular acceleration of the target. Then, the LCOSS takes that range, and with the help of smoke and mirrors and lots of voodoo, comes up with the time that a bullet would take to fly that distance, the TOF of the round. OK, hold on to your seat, here comes the hard part.

The LCOSS goes back to the HUD and the snake line and assumes that you have been maintaining a steady plane of motion for at least as long as that TOF. The LCOSS now draws the pipper on the snake. The pipper represents where the bullets are now which were fired one TOF ago.

If somehow, the target happens to show up at that same spot, then it goes boom. Your job is to make the target show up at that

spot. Simple, right? Well, not really, but we will offer you some tips that should make a gun kill a bit easier. First, let us restate the main theoretical points.

2 LCOSS Theory and Assumptions.

a. You have been and will continue to maintain a constant plane of motion.

b. Your plane of motion approximates the bullet plane of motion.

c. You have to manoeuvre such that your plane of motion intersects the target's plane of motion. Ideally, you want your plane of motion to overlay the target's plane of motion, this is called 'tracking' the target.

d. You must always remember that the LCOSS is not tracking the target, it is only attempting to show you bullet history. Only you know where the target is, you must fly the target to the pipper. The LCOSS will not do this for you.

e. The pipper is where the bullet is now that was fired one TOF ago.

f. You want to stabilise the target in your plane of motion and hold it under the pipper for one TOF for a 'tracking' shot.

g. If you are attempting a 'snap shot,' the gun has to fired one TOF before the target gets to the pipper.

3 Gun Attack Techniques - Tracking Shot

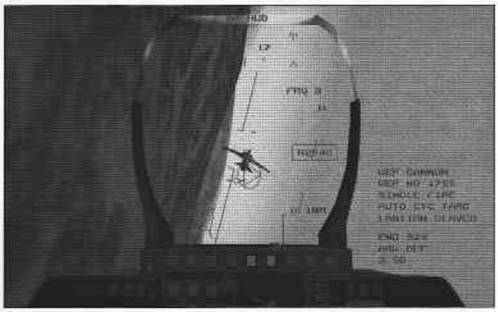


Figure 29 - In Range, In Plane, Open Fire

a. Disregard the pipper during your initial manoeuvring. Do not try to fly the pipper to the target. Try to stabilise the target in the middle of the HUD by getting into its plane of motion. Make your angle of bank the same as the target's. With that done, if the target stabilises in the middle of the HUD, you are in its plane of motion. If the target moves towards one side of the HUD, then you are in a plane of motion on the side of the target opposite to the direction it moved in the HUD. For example, if the target drifted left, you are flying to the right of its plane of motion. You must bank left slightly towards the target, bring it back to the centre of the HUD, and then roll gently back to the right to match its bank angle. Do this until the target does not move away from the centre of the HUD

b. Adjust your throttle to maintain minimum closure. Read your closure from the HUD target data. 50 knots closure is enough.

c. Once you have the target stabilised in the HUD, fly the gun cross out in front of the target and in its plane of motion. Make your control inputs very smooth and controlled. Now is not the time for jerky inputs.

d. Superimpose the snake over the target.

e. Now bring the pipper into your crosscheck. Smoothly increase or decrease back pressure to move the pipper to the target.

f. As the target moves into the pipper circle, open fire and hold the trigger down as the target flys though the pipper or is stabilised under the pipper.

g. Manoeuvre out of the way of the flaming debris.

4 Gun Attack Techniques - Snap Shot

a. A 'snap shot' is a non-tracking gun shot. It is defined as any time you shoot at a target whose plane of motion is not aligned with yours. Think of it as shooting at the target as it crosses your flight path.

b. Since the target is not in your plane of motion for any length of time, the number of bullets that may hit it is minimal. Therefore, snap shots have a much lower PK than a tracking shot.

c. The central idea of a snap shot is to stabilise your nose to get a reliable LCOSS computation. This means constant G and constant aircraft attitude. It does not matter what that attitude and G are as long as they are constant. You need this constant attitude so that you know where your bullets will go when you fire them.

d. You must be able to predict your target's plane of motion. For you to do this, the must maintain a fairly stable flight path.

e. With the target's plane of motion in mind, you then fly your nose to a position in front of the target's flight path.

f. Then you stabilise your attitude and compare the pipper to the target's flight path. The target must be moving towards the pipper. You must maintain a steady attitude and G load to allow the LCOSS to compute a bullet reference point.

g. You must open fire one TOF before the target gets to the pipper. Since TOF is a function of range and closure, it is impossible to give you a hard and fast lead point for all situations. One suggestion is to open fire using the diameter of the pipper circle as a rough ruler. We suggest you use at least two diameters as an approximation, more may be needed.

h. As before, immediately break away after firing.

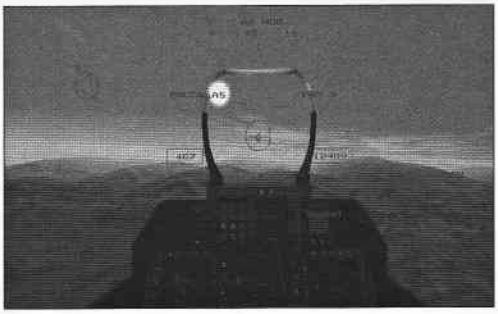


Figure 30 - Break up and Away

Basic Defence Considerations

It has often been said that the best defence is never having to get into that position in the first place. All well and done, of course, but there

just might come a time when the next to impossible happens, and you find yourself on the wrong end of the fight. In the well-known article on fighter tactics, 'No Guts - No Glory,' the author makes the point that there is no such thing as defensive manoeuvring. Instead, he emphasises that we should think of such manoeuvring as 'counter-offensive'. His point is well taken. If ever threatened, our best plan of action is to do whatever it takes to get back on the offense as quickly as possible. With that frame of mind well in place, let us now look at some specific considerations.

1 **Recognising When You Are Threatened.** Our MAW and RHAW avionics provide us with an excellent array of warnings and counter-measures. These visual and aural warnings are your best indicator of impending attack by a threat. If there is any drawback to their effectiveness, it is that they come somewhat late in the game. Ideally, you would like your Situational Awareness (SA) to be good enough to head off a potential threat before it gets to the point where it activates your avionics. There are a few ways of helping to make this so.

a. **Avoid Furballs Whenever Possible.** If there was ever a place where your SA was to take a major hit, it would be in a furball, a swirling, multi-bogey, visual fight. You can be sure in such a situation that if you can see them, they can see you. The F-22 is an excellent manoeuvring platform, but it is not bulletproof. Neither are you. Avoid furballs. Reposition or blow through. Get away from the immediate area of the fight, and then re-assess the wisdom of a reattack. Better one kill and a successful return to base, than several kills made in the sure knowledge that your buddies will be drinking to your memory later on.

b. **Watch Your EMCON Level.** Remember, your RHAW and MAW are affected by your EMCON level. This can be a particular problem if you are in manual EMCON. Do your fence checks. Make sure you have your systems working for you, not against you.

c. **Keep Your Mach Up.** 'Slash and extend'. 'Straight lines and hooks'. 'Never turn at the merge'. 'Belly check, belly check, belly check'. 'Speed is Life'. These are the 'golden rules' of air combat. A reading of the history of successful combat pilots makes one thing clear again and again, they never slowed down, they avoided the turn and burn, they always looked for the straggler. Not exactly the stuff Hollywood movies are made of, but real life seldom is. Keep yourself out of danger by using the 'slash and extend' technique. Attack at high speed - supersonic.

Take your best shot and then extend away. Minimise your turning, fly in 'straight lines'. If you must turn, then slow down to your best turning speed, 350-400 knots and then turn hard. Think 'hook turns.' Once out of the turn, accelerate back to warp speed. Avoid turning at the merge, and NEVER turn at the merge with no tally. If you are unsure of the position of your target at the merge, then extend on through and re-assess the situation when well clear. 'Belly checks' will prevent the enemy from attacking unobserved. And lastly, speed IS life.

d. **The Importance of Neck Hair.** Fighter pilots were born with an extra-sensory piece of avionics known as the 'hair on the back of your neck.' This equipment is far more reliable than the best RHAW gear ever made, is unaffected by anything other than poor judgment, and is always 'powered up.' Ignore it at your peril. If a situation 'doesn't feel right, it probably isn't'.

2 **How To Acquire The Threat**. The simplest way to acquire the threat is to press the F3 key. It provides either a HMD or external view look at the threat. In addition, the MFDs provide a longer range look at your situation. If there are multiple threats, you can easily see which one has you singled out by noting the white lock-on line extending from him to you.

a. Remember when using the HMD view in F3 that the enemy data shown is for the first target in your shoot list. If you have not targeted a threat, then no data will be shown in F3. You can put the threat in your shoot list and thereby get data on it by pressing the S key.

b. Your first order of business is to determine which side the threat is coming from. The MFDs make this pretty clear. If you are using the HMD F3 view of the threat, then there is an excellent chance of you becoming confused about threat bearing. Remember to use the canopy markers properly, the thick leg is nearest the canopy rail and the markers point forward. Most situations require a turn into the threat, particularly in a visual fight. The only exception is when you are being threatened by a long range missile shot, and even in this case, you must still know which side the attack is coming from.

3 **Missile Defence.** Your defence against a missile attack is predominated by your MAW countermeasures. In this simulation, manoeuvrability as a defence is subordinate to your electronic counter-measures. The Performance section includes an excellent missile defence technique and explanation.

4 **Gun Defence.** In the matter of defending against a gun attack, however, the MAW is useless. You are going to have to save your

own skin. For a successful gun attack, the attacker must be in gun range, must have the required lead angle, and must be able to fire bullets into your plane of motion. Here are the key points to keep in mind.

a. **Speed Is Life.** Most victims of gun kills are those fools who slowed down to mix it up with the bad guys. The best defence, again, is not putting yourself in that position in the first place. Slowing down and turning makes you very predictable and easily closed upon. Do not do this.

b. **Stagnate The Threat.** You do not want to let an attacker close to gun range. Your acceleration capability in the F-22 can allow you to deny the attacker any closure if you can acquire him soon enough. But you must not continue to turn, if you do, he will cut across your turning circle and rejoin on you. Use your canopy markers in the HMD view or the MFD to determine the threat bearing. Then turn hard to put the attacker at your six o'clock. Nose your aircraft down and dive to accelerate as you assess the threat.

c. **Know Your Area Of Vulnerability.** The attacker's gun is not magic. It can only hit you if you fly into its stream of bullets. To avoid this happening, you must be able to recognise where that bullet stream is. The bullet stream lies in the attacker's plane of motion. His plane of motion, like his lift vector, can be visualised by using his rudder or a line perpendicular to his wings. As the attacker turns, his bullet stream will follow his plane of motion. Your goal is to never be in that bullet stream.

d. **Avoiding The Bullet Stream.** First, you must never allow the attacker to get his nose pointed at you, and in particular, never, ever let him get his nose in lead pursuit. Once you see his nose becoming a threat., either pointed at you or in lead, then you must do something, like right now! The correct move is to get out of the bullet stream.

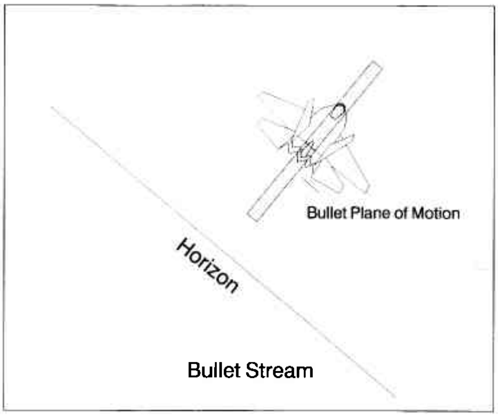


Figure 31

Pulling harder on the stick is not the way to do it. Additional G tightens your turn, gives the attacker more closure, slows you down, and worst of all, does absolutely nothing to get you out of the bullet stream. Instead you must manoeuvre out of the attacker's plane of motion. Do this by rolling approximately 90 degrees away from his lift vector. Roll to put your lift vector on one of his wing tips, If altitude allows, roll towards his low wing to take advantage of gravity. Once the roll is complete, then make a hard pull to move yourself out of the bullet

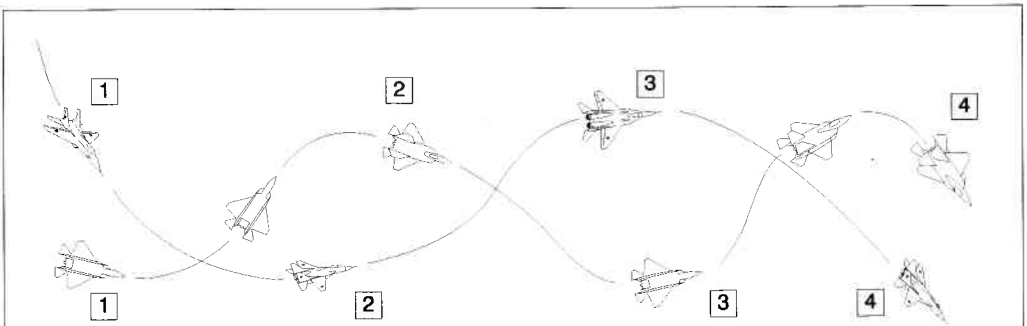
stream, then unload and accelerate to gain some distance. You can be certain that the attacker will reposition. Be prepared to repeat this procedure.

e. **Regaining The Offensive.** Now that the attacker has gotten our attention, we will want to make him pay for his sins. We want to make the shooter become the shootee! This is possible, but it will take considerable skill and daring. Assuming you have these in considerable abundance, a safe bet, let us explain what we are going to have to do.

f. **The Overshoot - What You Need.** To achieve a role reversal, you will have to create an angle off and aspect angle problem for the attacker that he cannot handle in the time available. Your objective is to force the attacker past your 3-9 o'clock.

g. **The Overshoot - How You Achieve it.** The attacker wants to be in your 5 to 7 o'clock position with little to no overtake. You want to manoeuvre to push him out on your wingline with excess airspeed. You want to manoeuvre to increase his aspect angle. You may attempt this using hard turns or throttle changes or both. The important word here is 'attempt', and that is because a competent opponent who understands how to use the vertical will be difficult if not impossible to force into a role reversal. But just like a faint heart never had amorous relations with a billy goat, you will not achieve an overshoot if you do not have a go at it. There are a number of ways of forcing a role reversal in this situation, we will describe two of the more common.

h. **The Level S Guns Defence.** This manoeuvre is similar to a horizontal scissors. It begins with the attacker close to firing range with you in a defensive turn. As the attacker's nose begins to establish lead on you, you unload and roll rapidly 180 degrees. You then pull hard away. Watch the attacker. If he



The level S Guns Defence

Figure 32

cannot follow you, he has been trapped in lag pursuit, and you may continue to extend. Most likely, the attacker will have the nose authority to roll after you and reattempt to pull lead. As he brings his nose to you, you will again unload and roll 180 degrees back into him, while making sure you do not pull back into his gun line. This second reversal will increase the attacker's closure and will move him out on your wing line. You may use speed brake and idle power at this time to accelerate his closure. As he continues to move forward, you then should roll to point your lift vector out of his plane of motion and pull hard out of plane. At this point, you and the attacker should be essentially neutral. If the second reversal does not result in the attacker moving rapidly to your wing line, then additional 180 degree reversals will be necessary.

I. The High G Roll Underneath. Whereas the Level S Defence is based on hard turns forcing an overshoot due to high angle off and aspect, the High G Roll Underneath Defence is a last ditch move relying strictly on an overshoot due to excessive closure. The goal in this technique is to force the attacker to literally blow right by you before he can react. You use this defensive move when you have little else left to try and is best attempted when your airspeed is low, below 300 knots. You begin again with the attacker in a low angle off six o'clock position in firing position. The manoeuvre is begun while you are in a defensive turn. While continuing to maintain your back stick pressure, you start a roll in the direction of the turn. Use rudder to accelerate the roll. Keep maximum back pressure and aileron/rudder in as you roll inverted and continue around in a descending barrel roll type of manoeuvre. Do not let off the pitch and roll input until you have regained an upright attitude. Thrust vectoring may be used to achieve a more pronounced angle of attack during the roll.

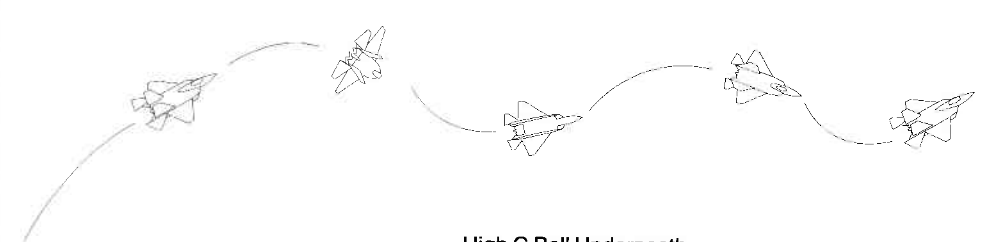

High G Roll Underneath

Figure 33

This manoeuvre very rapidly decelerates you relative to the attacker. The attacker often interprets the initial part of your roll as a Split S and will roll and try to follow you down. By the time he realises you are continuing back to level flight, he will have a nose down attitude and excessive airspeed that he will not be able to control in enough time to prevent him overshooting your wingline. Regardless of his corrective actions, you should be able to flush him out front. Your major difficulty in this manoeuvre is to maintain your tally ho during the roll. This manoeuvre is extremely violent and disorienting, but it works.

Disengagement

Of all our manoeuvres, the disengagement is the least difficult or sophisticated. The assumption here is that you are trying to leave a fight that is ongoing. There are three phases to your disengagement, the turn away, the extension and the regrouping.

1. **The Turn Away.** Your initial move is to manoeuvre to the belly side of your opponent. Try to force him into a high G turn and then unload and dive to the outside of his turn. Roll 180 degrees to him and pull hard to gain as close to an opposite heading as possible. Use the six o'clock view in **F1** or the **F2/F3** padlock to watch the attacker.

2. **The Extension.** While keeping your opponent in sight, keep your nose below the horizon and stay unloaded to maximise your acceleration. Remember that you need a lot of altitude to recover from a high speed dive, so keep your eye on your altitude. If necessary, descend to low altitude to use terrain masking for your disengagement.

3. **Regrouping.** Once clear of the immediate threat, check your MFDs for your wingman or other friendlies and the route map for your location and orientation. Do a fence check and then assess your follow-on plan.

Part IV Basic Fighter Manoeuvres

This section will discuss Basic Fighter Manoeuvres (BFM). The tone of this discussion will be more academic than the rest of this chapter. Our objectives are threefold:

1. First, we will explain what BFM is and explain some general BFM concepts.
2. Second, we will describe the most common BFM manoeuvres.
3. Last, and probably most important to you, we will suggest ways of flying these manoeuvres using the F-22 ADF/TAW player views.

What Is BFM?

Because this is an air combat chapter, we will refer to BFM in an A2A perspective, but you need to understand that all types of fighter manoeuvring is ultimately BFM. In the military fighter training schools, both initial and advanced, BFM is taught first. Later, when the student is introduced to ground attack, he is taught how air-to-mud is really just BFM against a fixed target on the ground. When the pilot is rejoining on his flight or the tanker, he is solving BFM problems. Ultimately, all fighter flying is just a matter of getting your airplane pointed in the right direction, with the right speed, at the right time, and with enough manoeuvring room to complete the manoeuvre.

All aircraft can roll, turn, and accelerate. BFM is a blend of these three basic manoeuvres to gain an energy and/or positional advantage on another aircraft. The purpose of gaining this advantage is to be able to fire a weapon at the enemy. The type of weapon and its characteristics will determine how much BFM is needed to employ it.

A significant point to always remember about BFM is that it is not an exact series of manoeuvres flown to reach a specific conclusion. Instead, BFM is a combination of complimentary manoeuvres that blend into each other, and which require continual reassessment to ensure the desired objective is met. When the pilot begins a BFM

manoeuvre, he also begins a process of observation, prediction, and correction. He first observes the position of his target. He then analyses target motion to predict where the target's manoeuvring will take it, and finally the pilot will correct his own flight path as necessary to maintain his advantage. With this in mind, let's look at some general BFM concepts.

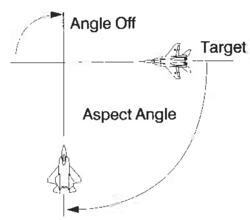
General Concepts of BFM

1 **Positional Geometry.** When you analyse your position relative to your target, you use three measuring sticks: range, angle off, and aspect angle. These three factors tell the tale of who has the advantage, you or your adversary.

a. **Range.** An easy one, simply the straight line distance between two aircraft.

b. **Angle Off.** Angle off is a measurement of differences in aircraft heading. It is the angular difference between the longitudinal axes of the attacker and defender.

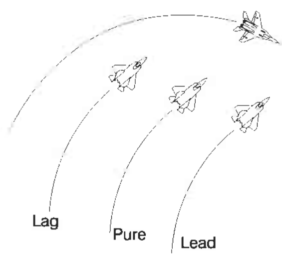
c. **Aspect Angle.** Of these three factors, aspect angle gives pilots the most problems in interpretation. Whereas angle off is a measurement of heading, aspect angle is a measurement of position. Aspect angle is the angle from the tail of the target to the position of the attacker. The attacker's heading is irrelevant.



Aspect Angle vs Angle Off

Figure 34

2 **Attack Geometry.** When you position your nose relative to your target, you choose one of three types of pursuit courses: lead, lag, or pure pursuit. When you point your nose in front of the target, you are in lead pursuit. If your nose is pointing behind the target, you are in lag pursuit. Point directly at the target, and you are in pure pursuit.



Pursuit Curves

Figure 35

3 **Out Of Plane Manoeuvring.** This concept is also known as split plane manoeuvring. The plane of manoeuvre of an aircraft is formed as its velocity vector moves through the sky. We call this its 'plane of motion'. The velocity vector is the aircraft's lift vector corrected for the pull of gravity. If another aircraft is brought into the picture, and its velocity vector is not aligned with the velocity vector of the first aircraft, then the two aircraft have planes of motion that are misaligned. Imagine two playing cards held together at cross

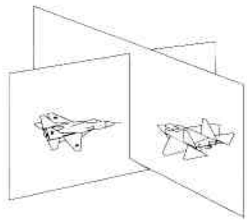

Split Plane Perspective

Figure 36

angles, the two card surfaces represent planes of motion. Because they are apart, they are said to be 'split'. When you manoeuvre your lift vector out of the plane of motion of another aircraft, you are manoeuvring 'out of plane'.

4 **Turning Room.** The concept of turning room is used in reference to the distance between a target and yourself. Your objective is to use that distance to bring your heading in alignment with the target. If the target is in a turn, then your objective is to be able to turn 'with' the target, 'with' in this sense means that you at least match the target's turn radius and rate. As you close in on the target, one of two things is going to happen. You will either be able to stay inside the target's turn or you will not - you will overshoot his flight path. How can you determine which will happen? There is one simple visual clue that you can use in the simulation. It has to do with aspect angle. This is how it works. As you approach the target in its turn, you want to look closely at the target's nose. Is it turning more and more in your direction? If so, then the target is increasing the aspect angle, he is becoming more 'nose on' to you. In your present position, you will not be able to stay inside the target's turn, there is not sufficient 'turning room' there for you to use. You must, instead, look for turning room elsewhere. That 'elsewhere' is anywhere that is out of the plane of motion of the target.

a. **Lateral Turning Room.** Lateral turning room is in the target's plane of motion. If you can match the target's turn performance, his turn rate and radius, then you can laterally turn with him. The main disadvantage to manoeuvring inside the target's turn is the loss of airspeed penalty associated with high G manoeuvres.

b. **Vertical Turning Room.** Turning room outside the target's plane of motion is called vertical turning room. Vertical, in this sense, does not mean the same as up or down relative to the horizon. Instead, it means relative to the target's plane of motion. Therefore, if you were to manoeuvre out of plane with a target that was flying a loop, your 'vertical turning room' is actually horizontal with the horizon. The main advantage of using vertical turning room is that you often can make use of the beneficial effects of G on your turn rate and radius.

5 **How Radial G Affects Your Turn Performance.** Radial G is the result of your lift vector being affected by gravity (God's G). Anytime your lift vector is pointed below the horizon, God's G is adding to its magnitude. Conversely, if your lift vector is pointed above the horizon, God's G is reducing its magnitude.

Anytime you can manoeuvre with your lift vector below the horizon, you are therefore getting a boost in turn performance, smaller radius and increased rate for a given cockpit G value.

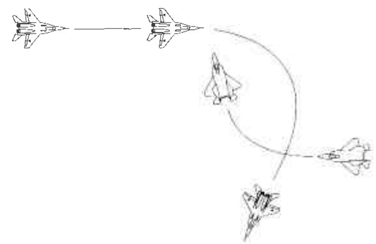

The Lead Turn

Figure 37

6 **Lead Turns.** A lead turn is the most efficient BFM manoeuvre, and has a simple definition. A lead turn is nothing more than an attempt to reduce angle off before you pass your target's 3/9 wingline. Lead turns can be flown in any plane, vertical or horizontal. The ideal situation would be to begin a lead turn when you had enough separation to complete the turn and end up at your target's six o'clock. This does not happen often. Instead, you usually start your lead turn without the required turning room, but you still gain an advantage by 'making angles' on the target by finishing with less angle off than you started with. One note of caution, if you can lead turn the target, by definition, he can lead turn you. Your turning room is also his.

Common BFM Manoeuvres

There are basic fighter manoeuvres that are used both offensively and counter-offensively. These manoeuvres are designed to:

1. Gain energy to achieve closure or to gain or increase separation.
2. Control effective overtake and decrease effective turn radius by manoeuvring out of plane of the target.
3. Decrease angle off or aspect angle by converting to lag pursuit while preserving nose/tail separation and energy for future manoeuvring.
4. Rotate your vulnerable cone away from an attacker and/or generate a turn rate sufficient to create an overshoot and possible role reversal.

Offensive BFM manoeuvres include the acceleration manoeuvre/low yo-yo, high speed yo-yo, quarter plane, and the lag/vector roll. Counter-offensive BFM manoeuvres include the break, extension, scissors, and the high G vector roll. There are numerous other BFM manoeuvres, but many of them are difficult, if not impossible, to perform given the limitations of our player views and the two dimensional computer monitor. The manoeuvres described here are 'flyable' and will achieve the objectives listed above.

Offensive BFM

1 **Acceleration Manoeuvre/Low Yo-Yo.** Typically, the first thing you want to do when you sight your target is to reduce your range to gain weapon launch parameters. You can get this closure through an increase in your airspeed, through cut off, or through a combination of both.

a. **The Acceleration Manoeuvre** is performed against a target that is not turning. It is performed by unloading your aircraft, selecting full power, and accelerating towards the target in a slight descent. All of this sounds pretty simple, and it is, but there are a few 'gotcha's' you want to look out for. First, if you need to turn to point at your target, then complete the turn before you lower the nose and add power. Once you have your nose down and airspeed increasing, turning will become less efficient, so point first, then unload. Second, be very careful about burying your nose in your acceleration. Gravity will help you lower your nose, and it will resist you bringing it back up again. As a rule, always keep the HUD and the target in view...if the target moves up and out of view, you have your nose too low. Once you have gained enough closure, 200 knots is plenty, then smoothly raise your nose turning only to centre the target in your HUD. Then finish your attack.

b. **The Low Yo-Yo** is an acceleration manoeuvre flown against a turning target. It is performed in a similar manner with the exception that the initial turn is made to point your nose in front of the target instead of at it. You want to establish lead pursuit on the target before you lower the nose, otherwise the technique is the same. As before, there are some 'gotcha's' in performing the low yo-yo. Along with the cautions mentioned above, you must be careful not to let the target's angle off and aspect angle become excessive. This can occur because the target continues to turn as you cut across its turning circle. As a rule, do not let target angle off exceed 45 degrees. If you see this happening, you need to terminate the yo-yo. You accomplish this by banking back into the target while raising your nose. Let your nose drift to lag pursuit for amoment, and then re-establish your lead pursuit. Check your 0 closure, do another yo-yo if necessary, and finish the attack.

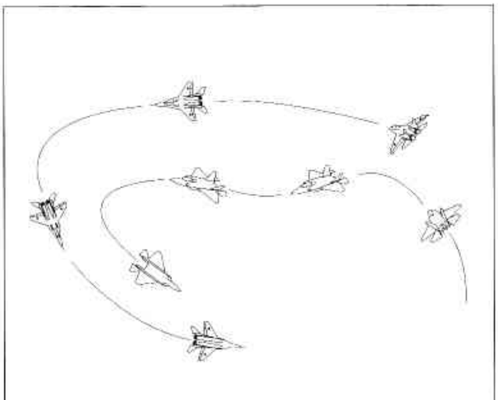
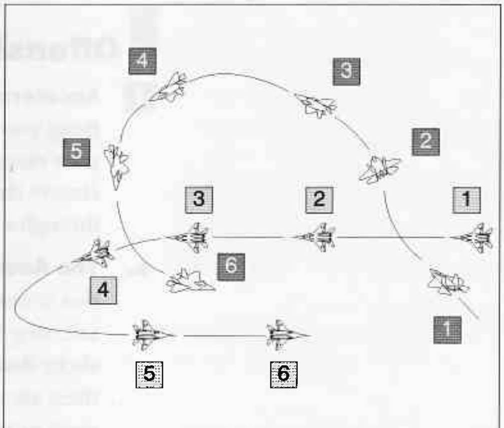

The Low Yo-Yo

Figure 38

1 **The High Speed Yo-Yo.** The High Speed Yo-Yo is designed primarily to be used in low aspect and angle off situations where you have excessive closure. It is also useful in solving some

moderately high aspect situations where you do not have the lateral turning room to make the corner. In both instances, you are in danger of losing your nose/tail separation. The solution is to rotate your lift vector and manoeuvre out of the plane of motion of the target. Your objective is to reduce your overtake by increasing the distance you fly relative to the target. You perform the high yo-yo by rolling to point your lift vector behind the target. Then you pull hard to raise your nose out of his plane, the amount that you raise your nose is directly related to how much overtake or aspect you are trying to control. You will know when you have your nose high enough when you see the target starting to move away from you. At this point, you will be high above his plane of turn and close to his six o'clock. Make an unloaded roll to point your lift vector back to a position of lead pursuit, and then pull down into the target.

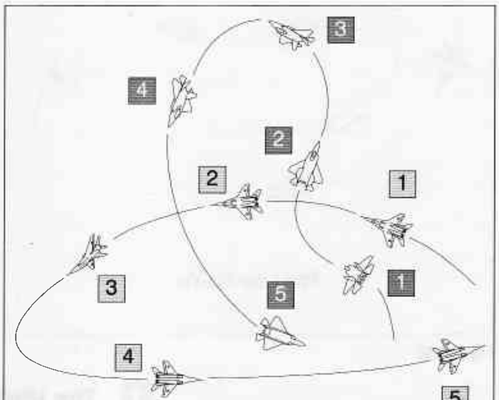


The High Yo-Yo

Figure 39

Common errors in performing the high yo-yo include (1) starting the manoeuvre too late which results in you overshooting the target, (2) starting the manoeuvre too early or yo-yoing too high which allows the target to separate, and (3) burying the nose in your pull down. Your objective is to descend back into the target's plane of motion with reduced closure. From that position, you should finish your attack.

3 **The Quarter Plane.** The Quarter Plane is a variation of the high yo-yo. It is essentially a 'last ditch' manoeuvre designed to preserve your nose/tail separation at all costs. It is typically required when the pilot fails to see the need for a high yo-yo until it is too late. The quarter plane is flown using hard and rapid control inputs, it's an 'emergency' procedure, and you do not need to be worried about being smooth. The quarter plane is begun with an unloaded, rapid roll to point the lift vector well behind the target. This results in a roll that is approximately 1/4 or more away from the target's flight path, hence the name, quarter plane. Then you aggressively pull the nose up. The amount of the pull up is proportional to the severity of the initial miss-match in angle off. Once the nose is up, you should roll unloaded to watch the target. As



The Quarter Plane

Figure 40

soon as you see some separation building, you should point your lift vector back into lead pursuit, pull back down, and re-enter the fight.

Common errors in performing the quarter plane include (1) starting it too late which results in a flight path overshoot. (2) Not pointing your lift vector far enough to the rear of the target which results in you losing your 3/9 line advantage. (3) Making a lazy pull up which allows the target to reverse, and (4) zooming too high above the target or delaying the pull down which allows him to extend away.

4 **The Lag/Vector Roll.** The Lag and Vector Roll are variations on the same theme. These manoeuvres are intended to allow you to reduce relative closure while correcting an imminent aspect problem. They both involve a roll around the flight path of a turning target. This roll reduces your relative closure because of the extended distance that you fly. The roll technique, when flown properly, limits any tendency for angle off to increase. These two manoeuvres differ primarily in the amount of G that you use in the roll. A lag roll is a relatively slow, smooth roll whereas the vector roll is a quicker, more aggressive roll. The decision on which type of roll to use is a function of range and closure. For slow overtake and longer ranges, use the lag roll. For high closure and short ranges, use the vector roll. You begin the manoeuvre from inside the turn of the target. You recognise the need for the manoeuvre due to the increase in angle off and high closure. To start the manoeuvre, increase your back pressure momentarily to try to reduce as much angle off as possible. Then, without reducing back pressure, begin a roll opposite the direction of turn. You want to fly up and over the flight path of the target. As you reach approximately 90 degrees of roll, you should be high and six o'clock to the target. Unload and roll quickly around to point your lift vector back into a nose in lead position. At this point, you play your back pressure to allow the target to move ahead enough to allow you to be able to pull back down. You vary your back pressure in the roll to control your overtake and to move your flight path up and over the target's flight path.

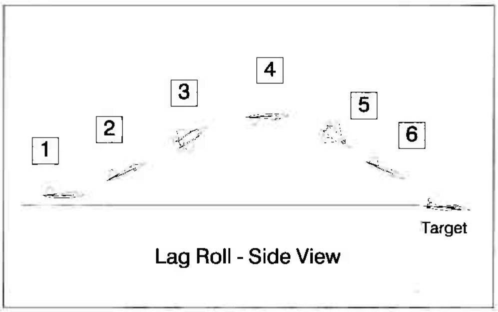


Figure 41

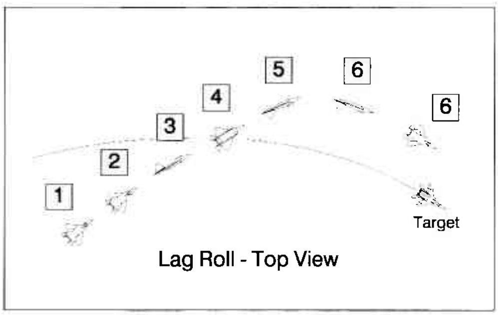


Figure 42

The top view of the lag roll illustrates the relatively constant heading the attacker flys from positions 1 to 5. Once the pilot has pulled up at position 2, he maintains no more than one G until position 5. The

target's turn and the attacker's forward movement result in the attacker reaching a high 6 o'clock advantage with his lift vector on the target. From there, the attacker can 'play' his pull down to control his range and closure.

Common errors in performing the lag/vector roll include, (1) starting the manoeuvre too late or with too much angle off. (2) Rolling with back pressure past the 90 degree point which results in even more angle off and a subsequent overshoot.

Counter-Offensive BFM

1. **The Break Turn.** The break is the most basic of counter offensive manoeuvres. It is an instantaneous, maximum performance turn into the attack. Depending on the type of threat, the break turn may be made in or out of the plane of motion of the threat. Missile breaks are usually made in plane and are intended to produce a change in missile line of sight that the missile cannot match. Missile breaks are flown against the missile, not the attacker. Gun breaks, on the other hand, are flown out of the attacker's plane to move you out of his bullet stream. In addition to avoiding the attacker's fire, the gun break also has the intent of causing the attacker to overshoot. The key to performing the break is lift vector control and the timing of the manoeuvre. The most common errors are (1) initiating the break too soon or too late, and (2) forgetting to orient the gun break out of the attacker's plane of motion.

2. **The Extension.** The F-22 has an excellent thrust to weight ratio. This allows the F-22 to gain airspeed rapidly, particularly when the nose is below the horizon. Use the extension to open up the distance between you and the attacker whenever the opportunity arises. The best time to unload and go for separation is anytime the attacker pulls his nose out of your plane of motion. For example, if the attacker pulls up for a high yo-yo, you counter that by extending away until he brings his nose back down to threaten you again. When you extend, roll your lift vector away from the attacker. There is always the chance that you have some G on your aircraft as you extend. This will cause you to turn slightly. If your lift vector is on the attacker, then you will be turning back into him. Common errors in performing the extension are (1) not unloading the aircraft, (2) burying the nose too far, and (3) allowing the attacker to arc you in the extension.

3. **The Scissors.** The classic scissors is a series of reversals performed by two aircraft, each attempting to drive towards the other's six o'clock. It is a low speed flying contest where victory

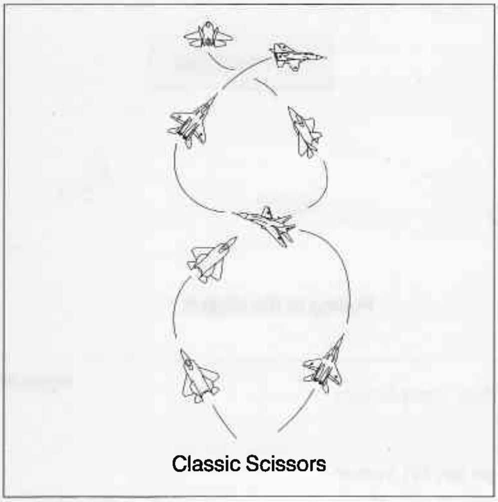


Figure 43

goes to the pilot most successful in controlling airspeed and lift vector orientation. The manoeuvring objective is to fly slower than your opponent while keeping your lift vector up and behind him as much as possible.

The stage is set for a scissors when an attacker overshoots, and the defender reverses. The end result is a series of reversals as each opponent tries to reduce his forward velocity to a minimum and thereby force his adversary out in front.

Two classic BFM manoeuvres are used to great effect in the scissors - the lead turn and the 'pull to high six', the orientation of the lift vector behind and above the opponent's flight path.

a. The lead turn is used in a scissors to gain an angular advantage on the opponent. The lead turn is initiated before the two flight paths cross. The pilot initiating the lead turn will reduce his angle off and minimise his lateral separation. His objective is to align his flight path with the opponent while continuing to maintain as vertical a lift vector as possible. Since the lift vector is most vertical when the wings are level, rudder is often used to change aircraft heading.

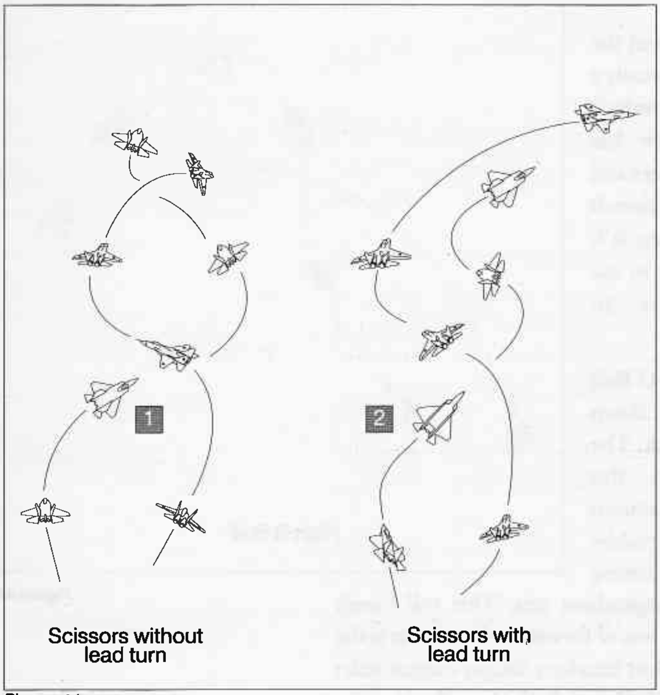


Figure 44

Positions 1 and 2 in Figure 44 illustrate the scissors lead turn. The pilot at position 2 has reversed his bank prior to crossing his opponent's flight path, unlike the pilot at position 1 who maintains his turn until he crosses his opponent's flight path. This early reversal allows the first pilot to remain inside his opponent's turn as the scissors continues.

b. The 'pull to high six' is the setting of the lift vector upwards and behind the opponent. This slows your forward motion and forces the opponent past your 3/9 line. Use maximum power and rudder the nose to point behind your opponent. You should make every effort to maintain a wings level attitude. Here is why. As bank

angle is increased, the stall speed for maintaining level flight is increased. As you bank, you lose effective lift and additional back pressure is needed to hold the nose up. This will require a higher airspeed. If you slow down through that airspeed, you will begin to stall. That will result in you descending below your opponent. This descent will give him additional room to manoeuvre to your six, and often results in an increase in airspeed that further complicates your 3/9 line problem by moving you forward.

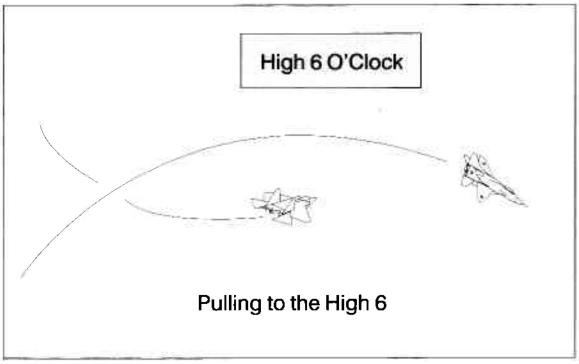


Figure 45

The winner of the scissors is the pilot who keeps his lift vector most vertical and speed the slowest possible without stalling. The loser is the pilot who fails in lift vector and bank angle control. If a pilot gets flushed out front, what are his options?

The corrective action for the pilot who loses the scissors is to minimise the separation between the two aircraft. He also wants to align his flight path back under the opponent as quickly as possible, if he can do this, his opponent will lose sight of him. Once under his opponent, the pilot should roll inverted and 'Split S' out of the fight.

The attacker should always avoid the scissors. The quarter plane is usually a better counter to a defender's reversal. Only the defender has something to gain from a scissors and then, only if his opponent's aircraft has poorer turning performance. It is usually wiser for the defender to use an attacker's overshoot as an opportunity to separate away.

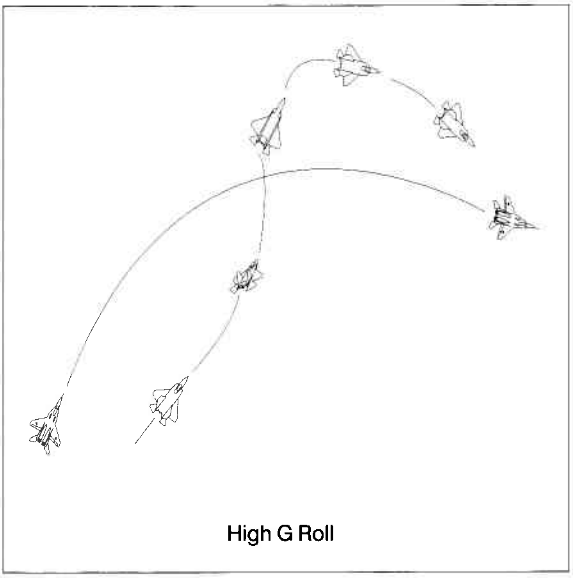


Figure 46

4 **The High G Roll.** The High G Roll is a last ditch manoeuvre flown against a determined gun attack. The basic flying technique in this manoeuvre is to blend maximum back pressure with aileron and rudder to achieve a violent rolling, yawing 360 degree roll about the longitudinal axis. This roll bleeds airspeed very quickly. It is this loss of forward velocity that is the purpose of the manoeuvre. Most attackers simply cannot react fast enough to the roll and end up being flushed out front.

The High G Roll can be flown 'over the top' or 'underneath.' The 'underneath' technique is discussed earlier. Use your airspeed as a rule of thumb to determine which type of roll to fly. If your airspeed is over 300 knots, go over the top, if under 300 knots, then consider going underneath, but watch your altitude. The main difference between the two is the amount of speed that is lost. The over the top manoeuvre can almost double the airspeed lost since gravity is working against the roll. The over the top roll is less disorienting to fly, and is depicted in Figure 46.

Because of the violent and disorienting nature of these manoeuvres, the hard part is keeping your attacker in sight. Remember, this manoeuvre is not an air show! You can expect the attacker to yo-yo or quarter plane off. If you lose sight of the attacker, look up once you are back to a wings level attitude. If the attacker has not simply flown past you to your forward quarter, then you may assume he has repositioned in the vertical. The defender's options at this point are to engage the attacker on more or less equal terms or to roll inverted and dive away in a separation.

Flying BFM Using The Player Views

In any air combat simulation, the 'proof in the pudding' is that simulation's ability to allow the pilot to manoeuvre effectively against his opponent whenever that opponent is not in the forward HUD view. F-22 ADF/TAW provides a choice of player views that are effective in providing you with the means to manoeuvre to bring your opponent back into the forward view. Apart from off-boresight missile employment possibilities, the forward HUD perspective is the most effective view for weapon employment. Any other player view has only one important tactical purpose, it is used to bring the opponent back into the forward view.

Despite the attention give to the BVR aspects of F-22 ADF/TAW employment, there will come a time when you find yourself in a visual knife fight. Indeed, for many fans of air combat flight simulations, the furball is what simulation flying is all about. Turn and burn enthusiasts, take heart! The player view techniques to be discussed will allow you to get in there 'amongst 'em' like never before. Let us get at it!

In the earlier discussion regarding player views, we made the point that F-22 ADF/TAW provided three views that are primary in keeping the target in sight. We also made the general statement that these views should be selected depending on whether or not the target was in visual range. These three views are the Forward View F1, the Player Target Padlock View F2, and the Threat Padlock View F3. Each of these views can be amended by pressing the respective key again.

1 **The Forward View.** The F1 view can be widened by use of the K key to give a wider perspective of the cockpit and surrounding airspace. This view can also be slewed using the hat switch to improve your look up or down, left or right. A second press of the F1 key will provide the forward view without the cockpit details. As long as your target is in the forward quadrant, you should use F1 for manoeuvring and weapon employment. We recommend that you return to this view anytime you manoeuvre the target back into HUD area. To minimise disorientation, we recommend that you not use the padlock F2 view to manoeuvre against a target in your forward quarter.

2 **The Target Padlock View.** The F2 view provides both an in cockpit as well as external view of the target. Refer to the player view section for an in depth discussion of these views. Our suggestion is that you use the padlock selection whenever the target is not in visual range. Use the canopy markers if necessary to bring the target to your nose. In visual range, we suggest pressing the F2 key again to select the external view. The external view provides an 'all in one' perspective of the three dimensional relationship between you and the target. For some simulation pilots, they find that BFM is more easily analysed and flown using this external view. Others prefer to remain in the padlock view regardless of target range.

When using the padlock view, you have a choice to make of two manoeuvring techniques. The difference between these two techniques is mainly one of difficulty in canopy marker interpretation and lift vector control. The first technique has already been described as the 'G for brains' approach to using the canopy markers. It is the easier of the two techniques to use, but it is also the less sophisticated or efficient.

a. Your objective in using the 'G for brains' technique is to place the centre canopy markers in the middle of your monitor screen and then pull until the HUD appears in view. From this position, you can switch back to F1 and press your attack. The main disadvantage to this technique is that it is an in-plane method that requires you to have a turn rate advantage over your target to be successful. If you do not have this turn advantage, you will never catch up to the target, you will just continue to pull and turn with no advantage being achieved.

b. The second technique that you may use with the padlock view is one of using the canopy markers to manoeuvre out of plane relative to the target. It is much more difficult to fly than the 'g for brains' method. The essence of this technique is to use the

outboard canopy markers and the target aspect pointer to orient your lift vector out of the target's plane of motion. When analysed correctly, this technique uses efficient BFM to bring the target into the HUD. This method does not require you to have a turn advantage over the target, instead, you use vertical turning room and radial G to out turn the target.

3 **The Threat Padlock View.** The F3 view is selected when you receive a warning from your MAW that either another aircraft has targeted your aircraft, or that a missile has been fired at you. As with the F2 view, you may select a cockpit padlock view or an external view of the threat. If the threat is a missile, then missile avoidance techniques should be followed. These are discussed elsewhere. If the threat is another aircraft, then the techniques used in F2 should be employed. Remember, the data in the HUD pertain to the first target in your shoot list, not the threat. To place the threat in your shoot list and thus be able to use the data in the HUD, press the S key.

Using The Padlock View To Manoeuvre Out Of Plane

Here is an example of how to use the padlock view to perform an out of plane manoeuvre, the High Yo-Yo. Let us set the stage by placing ourselves in a hard right turn behind our target. We are using the F1 view. The target is out-turning us and has just disappeared out the top of our view. Follow these steps:

1 Roll 90 degrees left and switch to F2 padlock. You will be looking to the right through the HMD. You will see the horizon line showing your wings level attitude, and the target and target triangle will be centred in the HMD. The target triangle aspect pointer will be moving clockwise showing an increasing aspect angle as the target continues to turn. You should see the right set of canopy markers pointing to the left towards your nose.

2 Start a pull up of 4-6 g's. The horizon will move down as your pitch increases. You are now climbing up and out of the target's plane of motion. If necessary, momentarily switch back to F1 to control your pitch...this out of plane 'climb' should not take more than a couple of seconds.

3 When the target aspect pointer reaches about the 3 o'clock position, it is time to reverse back into the target's direction. Unload, (relax your back pressure to one g) and roll smoothly until the centerline canopy markers are superimposed over the target. The markers should be pointing left and slightly down.

4 Now pull back on your flight stick keeping the centerline canopy markers centred. As your heading changes in this pull down to the target, you will notice the centerline markers rotating around to show your nose position. Eventually, they will point towards the top of the screen as the HUD comes back into view.

5 Continue to pull the HUD to the target. You may remain in F2 or switch back to F1 and finish your attack.

Ultimately, it is a toss of the coin as to whether you choose the 'G for brains' or the split plane technique. Try the 'G' approach first, and then as your proficiency increases, you might want to give the other a go. No matter, either one is effective in aiding you to manoeuvre the target back to your nose, and that is the bottom line.

Using The External View to Manoeuvre Out Of Plane

Once again we will put ourself in a hard right turn behind the target. We are flying in either F1 or F2/3 padlock view. When we recognise that our overtake or angle off is excessive, and the target is going to fly out of the field of view of the HUD, we decide to perform a high yo-yo.

1 If in F1 forward view, select F2 and press the key again to get into the external player to target view. If in either F2 or F3, press the respective key again to switch into the corresponding external view.

2 You are now in external view. The target is in front of your aircraft. Roll left until your lift vector (the top of your canopy) points in the direction of the target's left, 'up' wing. Your angle of bank is now approximately 90 degrees less than the target's.

3 Begin a 4-6 G pull up and hold the G until you see your aircraft pointed about 30-45 degrees above the target's plane of turn. The target should be off your right wing anywhere from your 1:30 to 3 o'clock position. The more initial closure or angle off you had to begin with will determine how long you 'hold' the climb and let the target drift towards your 3 o'clock position. This called 'yo-yo-ing off'.

4 Now, unload and roll right to point your lift vector back in the direction of the target. Your bank angle should approximate the target's. Pull back pressure to begin a turn to rotate your nose back to the target.

5 Once you have pointed back at the target, switch back to F2/3 or F1 and continue the attack. If your closure or angle off

continues to be excessive, repeat the procedure until you finally are in a low aspect/angle off position of kill.

6 The external view can be used to fly all of the BFM manoeuvres and is particularly useful when the target flys out of the field of view of the HUD. If you find that the canopy markers are difficult to use when attempting to manoeuvre out of plane, then the external technique might be for you.

Summary

Our objective in this chapter has been to give you tools, tips, and techniques to maximise your enjoyment of flying A2A combat in F-22 ADF/TAW. This simulation offers challenging entertainment for simulation pilots of all experience levels. Regardless of your playing style or game objectives, your study and use of the ideas presented here should prepare you well for air combat in the 21st century.

coordinates in the viewport, repeat the procedure until you finally are in a [illegible] off position of kill.

The external view can be used to the effect for [illegible] and is particularly useful when the target flies out of the [illegible] view of the HUD. If you find that the [illegible] markers are difficult to see when [illegible] out of plane, then the external technique might be for you.

Summary

Our objective in this chapter has been to give you such tips, and techniques to maximize your enjoyment flying [illegible] ADF/TAW. This simulation offers challenging entertainment for flight simulation pilots of all experience levels. Regardless of your playing style or game objectives, your study and use of the ideas presented here should prepare you well for air combat in the 21st century.

Chapter 7

A2G COMBAT

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A2G Combat

Whilst it is commonly regarded as less glamorous than air to air combat, the capability to deliver air to ground ordnance has nowadays become the main 'raison d'être' for all modern air forces. If you are at war, you want to destroy your enemy's capability to resist as fast as possible. A fleet of planes which just burn jet fuel looking for and shooting at the enemy air force is not the most efficient way to accomplish this - you also need planes which can deliver a considerable punch.

A plane specifically designed for an air to ground role would be the best solution, but the costs of modern combat planes have risen to a point where even the richest nations cannot afford to outfit their air forces with specialised, single role planes. Multi-role capability has become a buzzword in selling combat aircraft and therefore, even aircraft which were originally meant to be pure air superiority fighters now come equipped with the necessary hardpoints, computers and sometimes even air to ground radars to be quite efficient 'mud-movers'. All this despite the fact that 'if history tells us anything it tells us that tin-openers are better than Swiss army knives for opening tins'.

The F-22 is a case in point. Although its predecessor, the F-15 'no pound for air to ground' Eagle, has always possessed the capability to drop dump bombs, the original design specification for the YF-22 prototype called for the development of a stealthy air superiority fighter with no air to ground capability. However, this was later changed to include the necessary provisions to drop mud moving ordnance.

In DID's implementations of the United States next generation fighter, F-22 ADF and F-22 TAW, the air to ground capability has been included, and during the three Tours of Duty as well as in the Red Sea Operations add-on tours you will often come across missions where you will have to employ the assorted air to ground weaponry. Last but not least, air to ground combat will be the key point in the TAW campaigns, whether you win or lose a campaign will almost exclusively depend upon your ability to destroy ground targets.

In order to help you to become proficient in using A2G weapons, DID have provided some training missions. In marked contrast to the training missions found in EF2000, where it was rather peaceful and you could concentrate on becoming familiar with the switchology, the training missions in F-22 usually put you in the middle of a small scale battle scenario. It is not unlikely that you will look at your first couple of ACMI recordings just to figure out what killed you.

However, there are ways to overcome these hurdles. First, there is always the option to adjust the difficulty level. Ultimately, playing a flight simulation is about having fun, and if you keep getting shot down at one of the higher levels (which does not count as fun in my book), you should not let some misunderstood sense of pride keep you from turning down the difficulty level. You should always keep in mind that every simulation player (the authors of this work included) have, at some point, started as a newbie with no idea what was going on. If you become proficient at one of the lower levels and start to get bored, you can always turn the heat back on.

And no matter at which difficulty you are playing, the following chapter will guide you step by step through the employment of all the air to ground weapons found in F-22 ADF, and it will also help you to survive the training missions long enough to actually drop or fire those weapons. In order to ease you into the game, the order in which the missions will be flown has been changed from the one presented in the game.

Part I Basic A2G Combat

Smart Weapons

Due to the extensive media coverage of Operation Desert Storm most people assume that Smart Weapons are a rather recent addition to the Air Force's arsenal. Well, they are definitely a bit older than that. First, albeit rather crude attempts at guiding bombs after their release from the aircraft date back to the Second World War. The German Luftwaffe employed a small number of radio guided bombs, usually dropped by the Heinkel He-177 against ships, but since the hit ratios were nothing to write home about, those first experiments did not lead to further development.

The basic design for the Laser and TV-guided weapons we know today dates back to the 1960s and the Vietnam War. In those days, the Circular Error Probability (CEP) for dumb bombs dropped from a Century Series fighter-bomber was measured in hundreds of feet, which usually made it necessary to either attack with a large number of planes or to execute more than one attack. However, the extraordinary well-developed Vietnamese air defences made each and every attack a very dangerous and costly affair, leading to the development of the first Laser and TV-guided bombs which both improved the CEP by an order of magnitude.

Except for the JDAM, which uses the Global Positioning System (GPS) to guide itself to the target, today's guided weapons are basically nothing more than refined successors of those weapons. Since the JDAM is the guided weapon which is the easiest to use, our first training sortie will be the JDAM Interdiction mission.

Mission 1

The JDAM Joint Direct Attack Munition

Mission Target

Air Defence Headquarters.

Mission Briefing

Although the accuracy achieved with today's Laser-guided bombs is sufficient for even the most difficult targets, they have one major

drawback. The launching aircraft (or an accompanying aircraft or someone on the ground) must paint the target until weapon impact. Therefore, no matter who actually lases the target, that person/plane has to expose itself to enemy fire for a considerable amount of time – not a very desirable state of affairs and something was needed to solve that particular problem.

Despite its complicated acronym, the JDAM is nothing but a bomb - quite sophisticated, but still, just a bomb. It is not a guided weapon in the classical sense but rather a weapon which knows exactly where it has to go. Usually programmed before takeoff with the co-ordinates of its target, it receives position data from the Global Positioning System after launch and uses that data to steer itself to the target. Hence, it does not need any kind of guidance from the launching aircraft after it has been released and is therefore a true 'fire and forget' weapon.

Flying the Mission

Although the DID mission briefing advises you to approach the target at low level, there is no need for that. Since you are flying a stealthy aircraft, you shouldn't have any trouble at all in this mission to get close enough to the target to launch your weapon whilst remaining undetected. Still, having said that, the most important task in the F-22 is to remain stealthy. When you enter the mission, the AUTO EMCON state will immediately switch to level 4 due to the presence of all the SAMs around you (Figure 1).

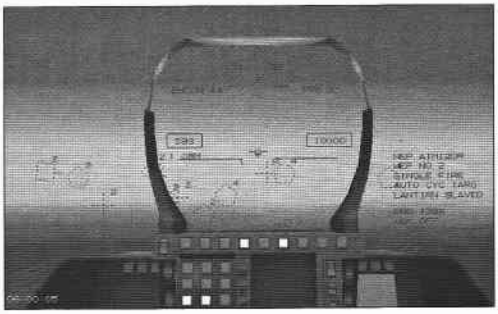


Figure 1

Unfortunately, flying around at EMCON 4 close to enemy SAM sites is a bit like waving a red flag in front of a bull with a really bad hangover – you will definitely get into trouble. Therefore, the first thing you should do when you hit the cockpit is to set the EMCON state to 1 (hit **E** and **1**). Next, select the JDAM as your active weapon **BACKSPACE** , throttle up and steer a bit to the left until you are flying directly towards your target (Figure 2).

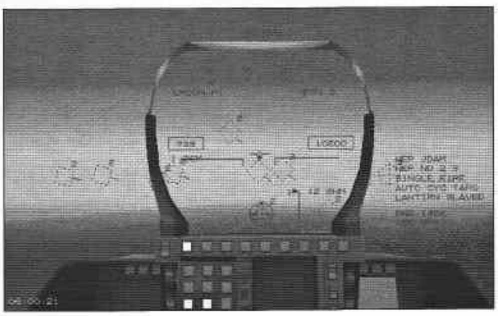


Figure 2

At this point, you have already done most of the work. Continue to fly towards the target and wait for the shoot cue to appear in your HUD. To make sure that the JDAM has enough energy to reach the target, wait about 2 or 3 seconds after the shoot cue has appeared before you release the weapon. With the weapon on its way to the target and the SAM sites uncomfortably close, it is high time to get out. Since no one shot at

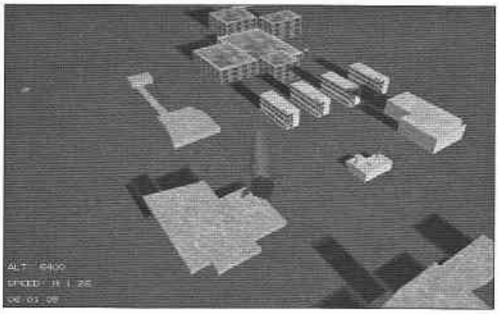


Figure 3

Figure 4

you when you approached the target, the safest way to get home is to fly along the same track. One of the quickest ways to reverse your direction is to perform a Split-S. Pull the throttle back, extend the brake, roll the plane until you are upside down and pull back on the stick until you have performed a half-loop. Retract the brake, advance the throttle again and make sure your nose is pointed comfortably above the horizon. If those preconditions are met, you can take the time and use the Missile View **F8** to watch the results of your work (Figures 3 and 4).

Mission 2

HARM SEAD

Mission Target

Airfield SAM defences.

Mission Briefing

In 1960, Gary Powers had the dubious honour to become one the first pilots to be shot down by a Surface to Air Missile (SAM), a Soviet SA-2. Since then, hundreds if not thousands of less famous pilots have shared his fate.

However, in 1958, even before the first aircraft had been shot down by a SAM, work had begun to find a way to neutralise this threat as well as the ever more deadly, radar-guided AAA guns (which later turned out to be the number one cause for aircraft losses in the Vietnam War). The first product of this development was the Shrike Anti-Radar Missile, later followed by the Standard ARM (STARM). Although those missiles turned out to be quite efficient, they both needed an active radar source to home in on. If the enemy radar operators simply turned their radar's off, both missiles would miss.

The High-Speed Anti-Radiation Missile (HARM), developed during the 1970s, fixed that deficiency by triangulating and 'remembering' a radar's position and, due to its high speed, was able to destroy a SAM site before the launched SAM could shoot down the launching aircraft, thus giving Wild Weasel crews the upper hand in their deadly game of chicken.

Flying the Mission

If you have not been quick enough in the preceding mission in switching your EMCON state to 1 or have been so cocky as to overfly the target, you will probably have some first hand experience about the deadliness of the SAMs in this game.

When you hit the cockpit in this mission, you will be at 20,000 feet, about 20 miles from your target. Since your airspeed will be rather low, advance the throttle and lower the nose a bit to pick up some speed, set your EMCON state to 1 and select the HARM as your active weapon (Figure 5).

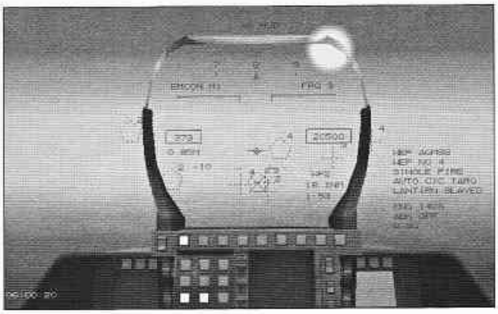


Figure 5

The next things you need to do is to build a shoot list for the selected weapon **T**, and to figure out which of the numerous SAM sites you are supposed to take out. If you are flying at the easy or medium difficulty setting, the mission objectives will be marked with a 'T', if you are flying at the hard setting, you would ordinarily use the IRST/FLIR display and your (hopefully) vast knowledge of what the enemy hardware looks like in this simulation to identify your targets. But since there are more than one Crotas and Jernas SAM launchers in this mission, take the two which are closest to the waypoint cross and appear as the top two entries in the shoot list (Figure 6).

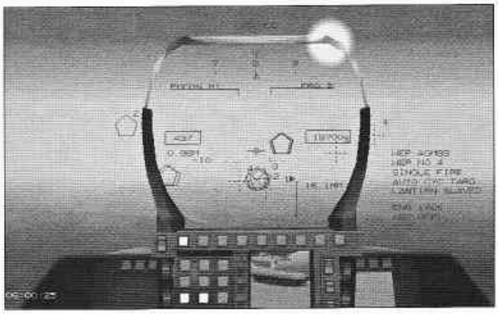


Figure 6

The maximum range of the HARM is around 14.5 miles, so you will probably have to continue to fly towards the target area for a couple of seconds. As soon as the shot cue appears in the HUD, launch all 4 HARMs (Figure 7).

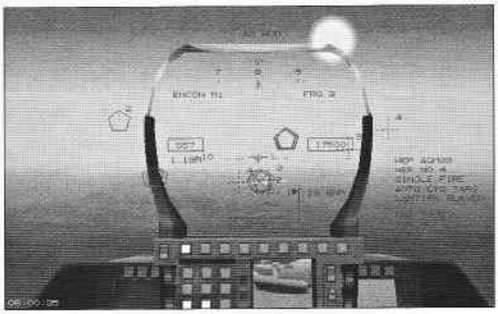


Figure 7

Since the HARM falls into the 'fire and forget' weapon category, there is no reason for you to continue to head into Indian country. Turn around before you use the missile view to appreciate your work (Figures 8 and 9).

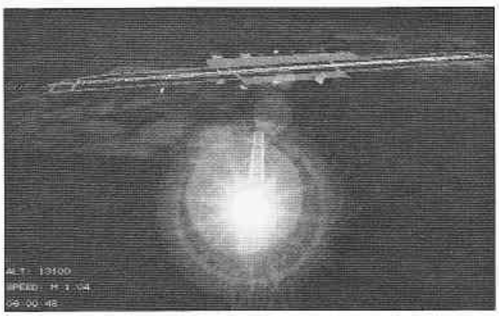


Figure 8

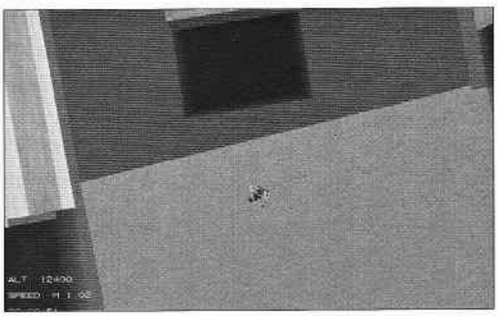


Figure 9

Mission 3

Bomb LGB

Mission Targets

Factory building and T-80 MBTs.

Mission Briefing

Whenever there is a need to hit very small targets or to avoid collateral damage, Laser-Guided Bombs (LGBs) come into play. Although in principle nothing more than dumb bombs upgraded with an add-on package consisting of a laser seeker, steerable fins and a couple of circuits, these additions make it possible to achieve a remarkable degree of precision. In Operation Desert Storm, LGBs were the weapons which made the news, they destroyed buildings, HAS, bridges, tanks and even a helicopter in flight (this extraordinary feat was accomplished by an F-15E Strike Eagle crew).

Although there are a multitude of LGBs with distinct weights, different fin layouts and guidance packages, you will only get to use one type of LGB in F-22, the GBU-24. Unfortunately, the option to buddy-lase a target (or to have it lased by another aircraft for you) is missing as well, and neither will ground troops lase a target for you. In F-22, you will always have to self-lase your target, which makes it even more important to become proficient at it.

Flying the Mission

The bad news about this mission is the fact that this is the first mission where it becomes unavoidable to devote some attention to the enemy elements which lurk around in all the training missions. In order to have a chance to complete this training mission, you will have to take out an enemy flight consisting of two Su-27s. If your air combat skills are not quite up to it yet, do not hesitate to reduce the difficulty level to the easy setting. Changing it will only marginally influence the air to ground part of this training mission (the two tanks you should kill will be marked with the 'T' target marker), but it will make the task of killing the enemy fighters, which should not be in a basic air to ground training mission in the first place, significantly easier. The good news is that you will have a wingman, so the odds for the air to air part are even.

In this mission, you will have to co-ordinate quite a few things rather quickly and in case things become too hectic, remember that you can always pause the game to take a breather.

When you hit the cockpit, you will be 14 miles from the target, at 10,000 feet and flying at Mach 1.0. Since there is some enemy AAA deployed near the target, make sure you stay above 6,500 feet at all

times. The enemy fighters are still 60 miles away, you should have enough time to overfly the target once and to take out one of the targets on that pass. Set your EMCON state to 1, the throttle to about 80 percent and make sure you are flying level and directly towards the target. Go to the attack MFD ('3' on the numeric keypad) and click on the button marked 'L' to call up the Lantirn display. Set the Lantirn mode to 'Free' by clicking once on the LANTIRN Mode button (marked with 'LM'). Use the cursor keys to point the seeker head towards the target area and click on the Zoom button (marked 'ZI') to enlarge the image. The factory should is pretty easy to recognise, it sits smack in the middle of the target area (Figure 10).

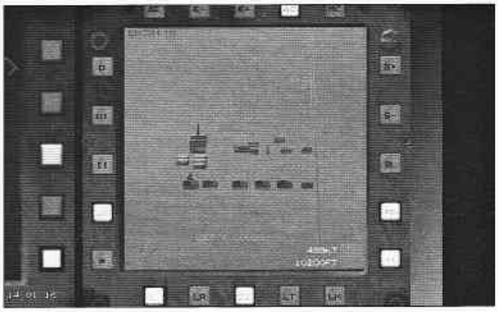


Figure 10

Again, use the cursor keys until the cross lies smack over the factory and press the Tracking button (marked 'LT'). Sometimes, there is no way to convince the LANTIRN system to track precisely the spot which you had in mind, it tends to jump around a little. However, even if the box is not completely centred over the target, close is close enough for now (Figure 11).

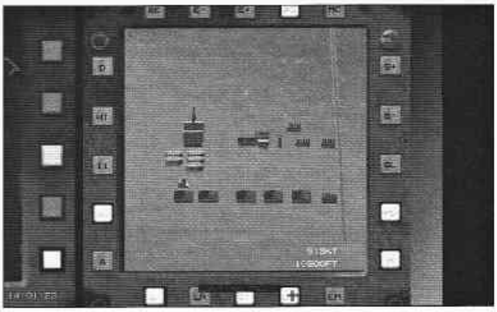


Figure 11

If things look more or less like Figure 11, you are all set. Wait for the shot cue to appear, and as with the JDAM, release the weapon 2 or 3 seconds after the shot cue has appeared to make sure that you release the weapon in the middle of its envelope. If the tracking box is not precisely centred over the target, make constant, small adjustments with the cursor keys to keep the box over the target. When the TTI (Time To Impact) counter reaches zero, you should see a nice, big explosion on your LANTIRN display.

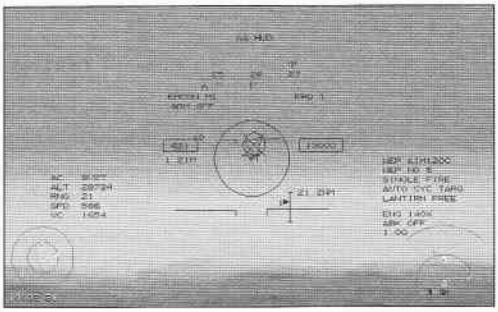


Figure 12

By now, it is time to take care of the enemy fighters. Switch to EMCON 2, select the AIM-120 as your active weapon, generate a shoot list T, tell your wingman to engage the bandits (hit 1 three times) and go back to EMCON 1 again. Continue to close the range, and resist the temptation to fire as soon as the fighters come into AIM-120 range, your chances to score a hit will improve if you wait until the missile circle in the middle of your HUD has become a bit larger (Figure 12).

Since you are at EMCON 1, you have to activate your radar manually by going to EMCON 3 before you can fire an AIM-120. Do just that, and fire two AIM-120s at each of the fighters even if your wingman

has already fired at them. You can easily afford to waste a couple of AIM-120s, the point of this exercise is to practise the use of LGBs, not how to fight enemy fighters whilst burdened with A/G weapons. After you have fired at the fighters, switch back to EMCON 1 immediately and get out of Dodge. Unless you are very unlucky, the enemy fighters should be destroyed by the missile salvo and we can re-focus our attention on the mission at hand.

By now, you are probably about twenty miles away from the target. Re-orient yourself, turn towards the target, set your speed to about 400-450 knots and, in case you are lower, climb to at least 6,500 feet. Go to the Attack MFD, reset the LANTIRN display by clicking on ('LR') and select the 'Slaved' mode (click on 'LM') if it is not already selected.

Finding such comparatively small targets as tanks on the LANTIRN display is a rather frustrating exercise. A much easier way to accomplish this task is to take advantage of the fact that the LANTIRN seeker can be tied or 'Slaved' to the targeting system.

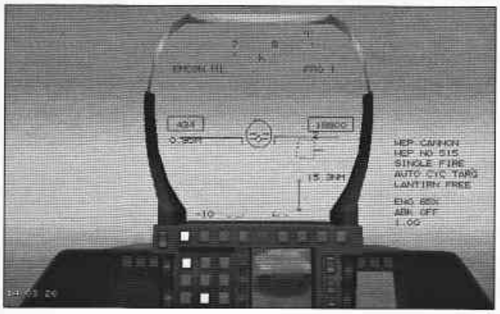


Figure 13

When you are about 15 miles from the target select the cannon (in the A2G mode) as your active weapon and generate a shoot list. Now, look at your up-front IRST display and toggle through the list until the first tank appears on the display (Figure 13).

Now select the GBU-24 as your active weapon. Although the display will zoom out again, the tank should still be locked up. Wait for the shot cue to appear, and release the bomb after the customary 2-3 seconds delay.

After you have destroyed the first tank that way, continue to fly straight on until you are about 10 miles from the target to give yourself enough room to set up the next pass.

Turn towards the target, select the cannon as your active weapon and go through the shoot list until the remaining tank appears in the display. Switch to the LGBs and dispatch the second tank just like the first. With the second tank gone, you will get the 'Mission Goals achieved' message and can end the mission.

Ordinarily, we would now move on to the next mission. However, I would suggest that you fly this mission again, though this time, use it to practice the use of LGBs as you will need to employ them in the TODs and the campaigns. Although LGBs were used to destroy tanks during Operation Desert Storm, there is no mission in F-22 ADF or TAW in which you will be called upon to do this. You will, however, come across a mission where you will have to take out four buildings with four LGBs - no margin for error. I would therefore suggest that you, after the first pass and killing the fighters, try to take out three

buildings with the remaining three LGBs. Continue to fly this mission until you can consistently take out four buildings with your LGBs.

Mission 4

Harpoon Ship Kill

Mission Targets

1 Type 23 Class Destroye.r

2 USALT Class support ships.

1 Ferry.

1 Container ship.

Mission Briefing

Approaching a group of armed ships at sea with the intent of dropping bombs on them has always been a rather risky business for aircraft. A flat sea offers the attacking plane no chance of a masked approach and gives the AAA gunners and SAM operators on the ships in question a comfortable margin in which to detect, lock onto and fire at the incoming attackers.

Consequently, when missiles finally became 'smart', it was only logical to develop an anti-ship missile to take advantage of the stand-off distances they offered. The effectiveness of this new class of weapons become first apparent during the Falklands War, when the Argentine Air Force sank two British ships with the French-made Exocet missile.

In F-22 ADF, you will use the U.S. made Harpoon anti-ship missile. Radar-guided, with a range of 32 miles, it will allow you to sink ships without even remotely running the danger of drawing enemy fire in return for the favour.

Flying the mission

Whilst you are supposed to sink five ships, you will only be armed with four Harpoons. Although the two additional Mavericks you are carrying would do in a pinch, you could also use this mission to practice how to employ your wingmen in F-22 against ground targets. Since you will be accompanied by three of them in this mission, the odds that one of them will manage to hit one of the ships on the list are pretty high.

When you hit the cockpit, you will be 40 miles away from your targets, heading towards the thickest concentration of ships. Except for one of the supply ships, which trundles along a bit lonely at your one o'clock, all your mission targets are directly in front of you.

Set your EMCON state to 2, select the Harpoon as your active weapon and generate a shoot list. Now, instead of engaging those

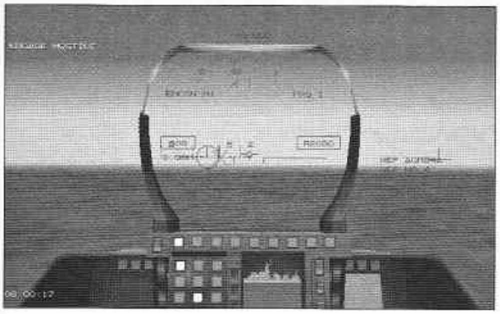


Figure 14

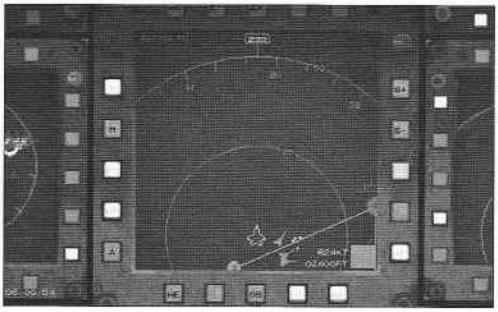


Figure 15

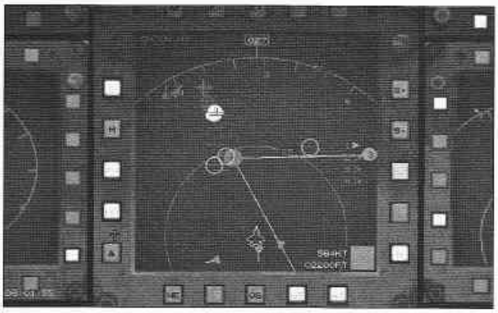


Figure 16

targets yourself, order your wingmen to engage them by pressing [1] three times (Figure 14) and make sure to go back to EMCON 1 to become as stealthy as possible again.

Since you want to save your Harpoons for the remaining targets, clear your shoot list [U] and turn away either 90 degrees to the left or right, since there is no need to get closer to the targets and run the risk of drawing fire at this point. By now, your wingmen should have launched their missiles as ordered (Figure 15), and you should wait until their missiles have reached their targets before you start your attack run. Usually, your wingmen will manage to take out the Type 23 class destroyer as well as the smaller, Gepard class fast attack ships, leaving the ferry, the container ship and the two supply ships for you. Since there are quite a few more of those ships left, the automatic generation of a shoot list at this point would probably place a couple of those in your list. Therefore, it is best that you build the shoot list for your Harpoons manually. It is fairly easy to do, go to the Situational Awareness MFD ([2] on the numeric keypad) and use the mouse to click on the targets you want to include in the list. For the combatants, you will get a data readout in lower left corner of the display with the class name, the ship's heading and the distance to it. For the non-combatants, you will have to use the up-front display to determine whether you have selected the right ones. If your Situational Awareness MFD looks like Figure 16, you are ready to run in.

Since the Harpoon does not posses any off-boresight capability to speak of, you will probably have to turn a bit and head towards the selected target before you will get the shot cue (apart from the obvious precondition of being in range, which in the Harpoon's case is 32 miles). With all four missiles off the rails, it is time to head for home and to use the Missile View to watch the fireworks.

Mission 5

Maverick Mobile Attack

Mission Targets

6 T-80 MBTs, 2 Mi-24 Hind Helicopters.

Mission Briefing

Even the best mud-moving pilots have trouble achieving consistent, good hit ratios when they drop dumb bombs on moving, heavily armoured targets. In addition, it has become standard practice for all modern armies to have their tank battalions protected by mobile AAA and SAM launchers, thus adding a considerable element of danger to an already very difficult task.

The Maverick missile was conceived to overcome both difficulties. First, it can be launched from a reasonable stand-off distance out of the range of most mobile defence systems. Second, its simple, yet highly efficient 'Lock, launch and forget about it' mode of operation makes it a very precise weapon, with hit ratios in the high 90s.

Although already relatively easy to employ in real life, the Maverick in F-22 is still a bit easier to use. In reality, the lock-up process is very similar to locking up a target for a LGB. In F-22, you just have to build a shoot list, select your first target, pull the trigger and select the next target from the list - it does not get much easier than that.

Flying the Mission

This is one of the occasions where you get dropped into the mission just tiny little bit too close to the action, and if you do not react really fast when you hit the cockpit, the mission will be over before you realise what is going on.

The situation is the following. When the mission starts, you will be in a small valley heading due West, twelve miles from your targets, the tanks (Figure 17).

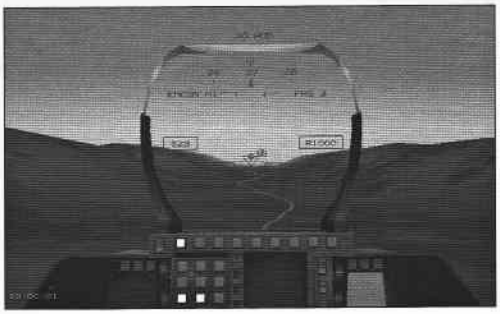


Figure 17

However, this group of tanks is protected by a ZSU-23/4 mobile AAA gun and an SA-11 SAM launcher. Since you are just about to enter the engagement envelope of the SA-11 missile launcher, the AUTO EMCON control will switch to level 4. If that launcher fires at you and you are playing at the 'Hard' level, you are as good as dead.

Therefore, the first step is to avoid being shot at. When you hit the cockpit, set the EMCON state to 1 immediately and start a climbing turn towards the right, out of the valley. The next step is to add the launchers to the Maverick's shoot list. Ordinarily, you would automatically generate a shoot list, but that will not work in this case. When you command the weapon computer to build a Maverick shoot list, it will note how many missiles you are carrying and build a shoot list with exactly that number of targets. The criteria used to determine which enemy vehicles are put into the shoot list is the distance, the closest gets in at first place, then the second closest and so forth, up to

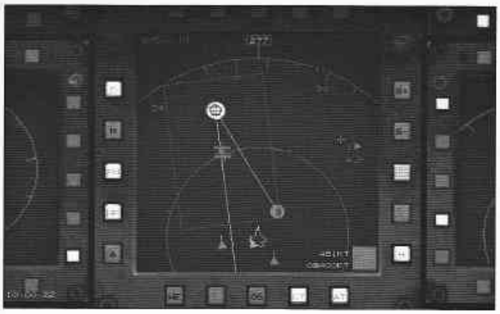


Figure 18

the maximum number. Usually, this works pretty well. In this instance however, there are a couple of comparatively harmless vehicles between you and the enemy air defences and hence, the ZSU-23 and the SA-11 are not put into the list. This is also the reason why your wingmen, whilst busily shooting up the place, never manage to hit the air defence units - their shoot lists will get filled with the closest vehicles as well.

Thus, you will have to build the shoot list manually. As an added difficulty, you will have to fly in such a way that the enemy does not become masked by the terrain or passes out of your forward field of view. In both cases, they will vanish from the display, and you cannot add them to the shoot list. However, whilst you have to take care to keep them in sight, you must also avoid flying into the engagement range of the missile launchers. Sounds complicated? You are right, it is, and if you initially find it a bit difficult doing this while also trying not to fly into the hills, you should not have any qualms about pausing the game and building the shoot list at your leisure (Figure 18). The point of this exercise is to learn the ropes, not to impress anybody.

Once you have built the shoot list, you need to extend a bit before turning around to launch your missiles, since you are probably pretty close to the SA-11 launcher by now. So, turn around and give yourself enough room to execute your attack.

Now that you have killed the air defences, you can start to look for your mission objectives, the tanks and helicopters. Usually, a couple of tanks will have survived your wingmen's missile barrage, and you should take care of them first. Just generate a shoot list (this time, you can let the computer do the work, there should not be that many vehicles left) and toggle through it until the first tank appears on your up-front IRST/LANTIRN display. Launch a Maverick and start to look for the next tank. Repeat this process until all tanks have been dispatched.

By now, you might have noticed that your wingmen have called out bandits a couple of times. There are, in fact, two MiG-27s inbound from due North, and depending on how long you need to finish off the tanks, you might have to interrupt your work to take care of them.

However, you should usually be able to finish the mission before they become really annoying (for example, starting to launch missiles at you).

In TAW, you are now finished. However, in ADF, you still have a bit of work left to do. In order to successfully complete the A2G weapon training mission for the Maverick, you have to kill two airborne helicopters. You might have noticed them buzzing around during

your ground attack runs. Even if you cannot detect them on your displays at first, they are usually still there, they are just not readily visible since they fly pretty low. Search the area to the south of the waypoint, they should be somewhere in that area.

When you have found them, select the Sidewinder as your active weapon, lock them up (remember that you have to put the internally carried Sidewinders into the open with a press of the trigger before the missile's seeker can 'see' the target) and launch one missile at each of them.

Dumb Weapons

By now you are probably convinced that smart weapons are the greatest thing that happened since the invention of sliced bread. Mostly, that is true. However, one problem with smart weapons is the fact that whenever a smart weapon explodes, the smart part goes up in flames with the target. Ultimately, this is very expensive. Therefore, the last 20 years or so have also seen a vast improvement in the weapons computers used to deliver dumb weapons. With today's modern avionics, it is now possible to deliver dumb weapons with a remarkable degree of precision as well. This can be done at a fraction of the cost of doing the same with smart weapons, since the 'smart' parts remain on or in the plane rather than detonate on the target. One major difference remains, however - all targeting has to be done by the pilot prior to weapon release, once the weapon is on its way, all bets are off.

Since you will play the pilot's part in F-22, this obviously means your workload will go up significantly, as the delivery of dumb weapons demands not only the knowledge how to set up the switches, but will also require you to fly very precisely to deliver the goods right on the money.

Mission 6

Bomb BAI

Mission Target

Warehouse.

Mission Briefing

Even when coupled with the latest generation of weapon computers, dumb bombs are still not quite as precise as their smart cousins. However, no air force can afford just to buy smart weapons and there are still enough targets where reduced precision is quite sufficient. Dumb bombs come in a number of choices, 500, 1000 or 2000 lbs., retarded or free fall. In this mission, we will use the Mk 82F, which is a free-fall, 500 lbs. bomb.

Flying the Mission

When you hit the cockpit, you will be at 15,000 feet, 15 miles from the target and the waypoint cross sits smack over the target. If you have played EF2000, you will now probably assume that the easiest way to accomplish this mission is to engage the autopilot and let him fly the plane precisely towards the waypoint whilst you just wait for the CCIP marker to cross over your target and to release the weapon at this point.

Unfortunately, there are a number of reasons why this will not work. First, you will be flying too high, at 10,000 feet (which is the altitude pre-set for the waypoint), you will never see the CCIP marker cross the target. Secondly, the autopilot will not cross the waypoint as in EF2000, it usually switches to the next waypoint at about 5 miles from the currently selected waypoint. Therefore, you will have to release the bombs manually, just like it should be. For this mission we will use a shallow diving attack with a dive angle of about 30 degrees.

As in the LGB mission, there are a couple of AAA units deployed around the target. Although there is a SEAD flight inbound tasked to destroy those AAA units, they sometimes do not get all of them. Since it is better to be safe than sorry, we have to be sure to stay out of their range in our attack. We will do this by initiating our attack from 20,000 feet, this way we should be able to drop our bombs and pull up again before we enter their engagement envelope. Thus, go to full throttle and climb to 20,000 feet.

In order to destroy the warehouse, you need to hit it with two bombs. Since you are carrying 12 of them and you only need to hit one target, there is no need at all to be a penny pincher. Thus, select the Mk 82F as your active weapon, go to the systems MFD, change the firing mode to 'SALVO' (either click on the button labelled 'FM' twice or press the E key twice) and increase the salvo size to four (click three times on the button labelled F1). When you are finished, your systems MFD should look like Figure 19.

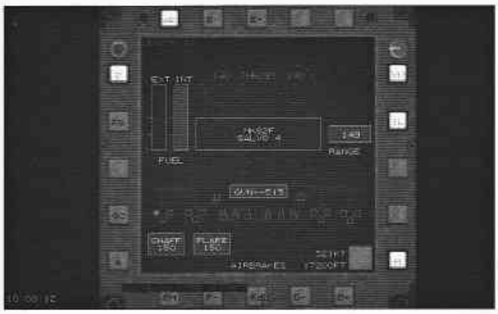


Figure 19

By the time you have made those adjustments, you should have reached 20,000 feet. Level out and make sure you are still flying directly towards the target. When you are 6 miles from the target, pull the throttle back to idle and push the nose gently over until you have attained a dive angle of 30 degrees (Figure 20).

Stabilise in your dive, make sure the bomb fall line runs right through the waypoint cross and wait for the CCIP marker to rest on the target. At the precise moment when it overlays the target, release your bombs (Figure 21).

It may be bit difficult to see, but the CCIP marker is just merging with the base of the triangle. You should also note that the altitude at the moment of the release is 7,100 feet, so you have enough of a margin to pull out and to stay above the AAA threshold altitude of 6,500 feet.

After you have released the bombs pull back sharply on the stick, go to full throttle and pull out of the dive. Once you are stabilised in your climb, switch to the missile view to watch your bombs hit the target.

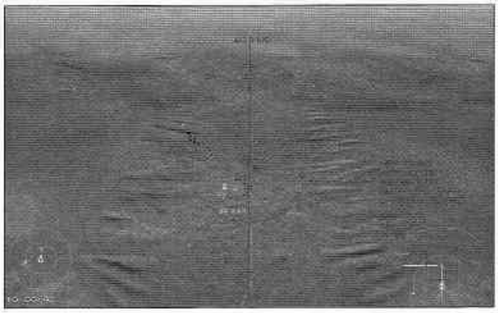


Figure 20

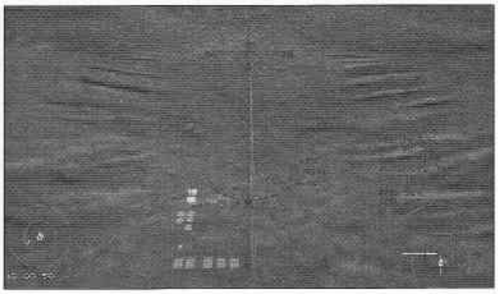


Figure 21

Mission 7

Cannon Strafe CAS

Mission Targets

3 Humvees, 2 Trucks.

Mission Briefing

The very first weapons to be fitted on aircraft were machine-guns, their use dates back to the First World War. Since then, machine guns have been replaced by cannons, whose rounds deliver a bigger punch, and the means to aid the pilot in bringing his guns to bear have also changed considerably. Nevertheless the basic principle of employing a gun has not much changed since WWI, the pilot has to point the whole aircraft at the target to bring his guns to bear.

During the years since they were first used, machine guns and cannons even went out of style for a short time. During the 1950s and early 1960s many so-called experts claimed that the air to air missile was the new champion in the air to air arena, and a couple of fighters developed in that area came without a gun, the F4 Phantom II being probably the most famous example. However, the Vietnam War corrected that misconception, and today, every fighter is again equipped with a credible, close-in weapon.

And even if the cannon would not be necessary for air to air work, it is still pretty useful against ground targets. In F-22 ADF and TAW, the M61A2 cannon packs quite a punch, however, in the upcoming mission, you only have to kill a couple of Humvees and trucks, and this falls well within the limits of the real world applications for the M61A2.

Flying the Mission

The valley in which this mission takes place should look familiar to you, it is the same in which you have sharpened your Maverick skills.

In this mission you will start a little closer to the action, when you hit the cockpit, you are just five miles from your targets.

An earlier strike has already taken out the enemy air defences, the only remaining disturbances are two Ka-50 attack helicopters and two MiG-27 fighters. You can pretty much ignore the helicopters, but the MiG-27s tend to become a nuisance if it takes you a while to get all the mission objectives. If you are playing at the 'Hard' level, you do not have many cannon rounds to spare, I would therefore suggest you assign your wingman the task to get the bandits.

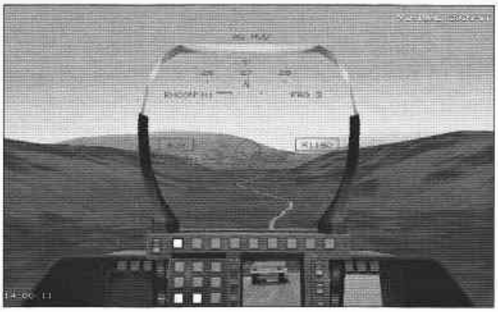


Figure. 22

Figure 23

Figure 24

With the bandits out of the way (do not worry, your wingman will usually get them), you can concentrate on the task at hand. Your targets are distributed between the two groups of vehicles in the valley. 2 Humvees and one truck are in the group that is following the road, the remaining Humvee and the last truck are in the group travelling off the road, initially crossing your field of view from left to right (Figure 22).

If you are used to EF2000's stationary ground targets, you will discover that it is definitely slightly more difficult to hit a small, moving target like a Humvee. However, it is still doable.

The first steps are to select the cannon as your active weapon (we need it in the A2G mode, so use **BACKSPACE** to select it) and to generate a shoot list. Use your up-front display to toggle through the shoot list until the first mission target comes up (Figure 22). Once you have selected it, use the HUD declutter key **J** to clear up your HUD picture.

Attacking a moving ground target is a bit like shooting at an airborne enemy, the smaller the target motion is in relation to you, the easier it is to hit the target. In order to minimise that motion, you should attack the ground mobiles along their line of travel, either from directly behind or from the front (Figures 23 and 24).

The actual attack should be performed in a shallow dive with a dive angle between 5-20 degrees, at a speed between 300-400 knots. Since you only have 515 rounds at the hard level, you can hardly afford to liberally hose the general area around your target. Put the piper a bit under the target, wait until the range clock has at least reached the 6 o'clock position, pull the piper up onto the target and open fire with

short, controlled bursts. Try to resist the temptation to hold the trigger down until you see your target explode. An additional danger in these strafing runs is that you become so fixated on your target that you forget to pull out - if you can see the red lights at the back of the trucks, you are definitely a tad too low and too close. Pull back on the stick, go to full throttle, extend and set up the next run.

Since you have to attack more than one target in each of the two groups, you will have to repeatedly attack the same group. If you, after an attack along the line of travel of one of the groups, just extend for a bit and perform a level turn, you will definitely find yourself at an odd angle towards that line of travel instead of smack on it. In order to keep your alignment for your repeated attack runs perform either a Slice- or a Split-S reversal (for a discussion of these manoeuvres please refer to Part II, 'Advanced A2G Combat').

After you have become proficient at strafing, you will find that you will usually have a couple of rounds left after you have destroyed the last mission target. In that case, you can either go for the remaining tanks or try your hand hunting helicopters.

Mission 8

Rocket Attack

Mission Targets

3 LCAC, 3 OSA2, 1 Ferry.

Mission Briefing

Although the cannon is a pretty useful weapon against so-called 'soft' targets like unarmored vehicles, supply pallets and humans, it usually does not quite hack it when it comes to targets that require a slightly bigger punch (this refers to real-world use, in this simulation, the F-22's gun is a bit more 'versatile'). Unguided rockets posses both a longer range and a bigger warhead than cannon rounds, neatly closing the armament gap between cannons and the next class of weapons, bombs.

In this mission you will go on a ship hunt with your LAU-68 rockets. Since ships tend to move just like landbound vehicles, the same considerations concerning the attack direction apply. However, since rockets travel significantly slower than cannon rounds, you also have to lead your targets a little, especially the small Hovercraft.

Flying the Mission

Once again, this is one of the missions where you have to hurry to ensure your survival as soon as the mission starts. This time, you will be dropped into the simulation right on the edge of the engagement envelope of a Gepard fast attack ship. As usual, immediately set the EMCON state to 1 and perform a break turn to the right. This Gepard

fast attack craft and its SAM systems will stay with us for the whole mission, but since the mission targets lie outside of its SAM envelope, it is more a nuisance than a real threat.

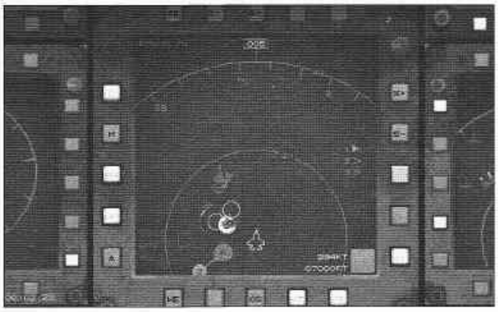


Figure 25

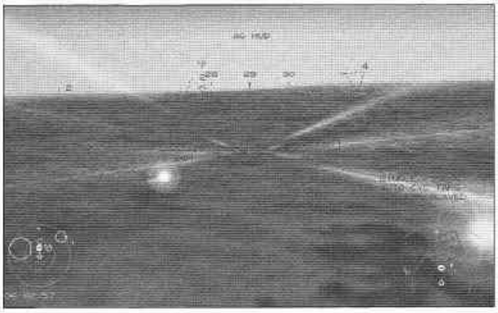


Figure 26

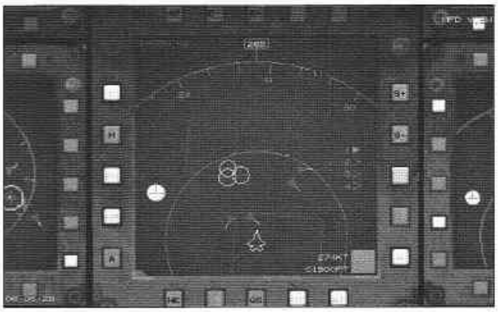


Figure 27

Now it is time to think about how to approach this mission. From the three different types of targets you will have to tackle, the OSA2 fast attack craft are the only ones which are armed, they have some nasty AAA on board. Therefore, they should be the ones you should attack first with your longest range weapons, the LAU-68 rockets.

Make sure you are flying level in a more or less easterly direction and go heads down to take a look at the Situation Display to find the OSA2s. Use the mouse to drag the cursor over the red ship symbols to get more info on the contacts, that way, you will discover the OSA2s on the far side of the Gepard. Since it would not be a good idea to fly through the Gepard's SAM circle to get to the OSA2s, fly counter-clockwise along its outer edge until you are in weapons range. While you are doing it, use the time to manually build the first shoot list, for now, just put the OSA2s into it (Figure 25).

Once you are clear of the Gepard, select the closest OSA2 and start your attack. A rocket attack is executed in a very similar manner to a strafing run. Fly towards your target at about 3,000 feet, and when you are about 3 miles from the target, pull the throttle back to idle, push the nose gently down until your rocket piper rests squarely on the target and launch your first salvo (Figure 26).

Continue to fire until the range clock reaches the 4 o'clock position. At about this distance, the enemy gunners will start to fire back and it is definitely safer to break off the attack at this point. If your first attack run has not done the job already, extend and re-attack, if your target just exploded, move on to the next one.

After you have dispatched all three OSA2s, it is time to look for the remaining targets. As before, use the Situation Display to find them and to build the shoot list (Hint: the ferry is represented by the only olive symbol on the display). When you are finished, your display should look like Figure 27.

As the ferry is the largest of the remaining targets, you should attack it first. Since it cruises just outside the Gepard's SAM envelope, you have to be a bit careful from which direction you approach it. Apart

from that, this attack is a milk run. The target is pretty large, and no one shoots at you. With the ferry gone, there are only the LCAC Hovercraft left to take care of.

Although this mission is supposed to be the rocket training missions, I would suggest that you use your cannon to dispatch the LCACs. Due to the fact that the LCACs are moving at a pretty good clip, simply pointing your piper at them and firing the rockets will not work. By the time the rockets arrive at the point at which you have launched them, the LCAC will already have moved on and your rockets will just vaporise a few gallons of water. In order to compensate for this, you have to estimate the required lead for the shot, not exactly a trivial task. Granted, the same problem exists for your cannon rounds. However, the cannon rounds have a much higher velocity, and the required lead is therefore considerably smaller - in fact, almost nil. In addition, you should have many more cannon rounds than rockets left and you can therefore more liberally fire at the area in question.

Independent of whether you attack the LCACs with rockets or the cannon, you should attack them along their line of travel, just as with the vehicles in the strafing training mission. The LCAC's course is 025, so your attack should be either along this direction or along the reciprocal bearing of 205.

With the successful strafing or rocket attacks you have executed so far under your belt, you should have trouble to getting the three remaining LCACs.

Mission 9

Cluster CAS

Mission Targets

3 Fueltanker, 3 Bedford Trucks.

Mission Briefing

The idea behind the last dumb weapon we will look at, Cluster Bombs, is to distribute a fairly deadly amount of explosives evenly over a defined area in order to give aircraft the means to fight ground troops more effectively. Since most mobile ground targets do not need much in the way of explosive force to be disabled, an ordinary dumb bomb usually results in an overkill at one place whilst leaving adjoining targets unharmed. In contrast to that, a cluster bomb spreads its explosive content in the form of submunitions over a wide area before the submunitions themselves detonate, thus achieving a greater spread of a smaller, but still quite deadly force.

Just like many other weapons in use today, cluster bombs were first used during the Vietnam War. Since then, the basic, 'just distribute the explosives' original type has been greatly improved and refined.

Cluster bombs can now contain such diverse submunitions as anti-armour or anti-personnel bomblets, delayed action bombs or anti-tank mines.

Flying the mission

In this mission, you will hit the cockpit 17.5 miles from your target, at an altitude of 14,000 feet. If you get a sense of deja vu when you enter the mission, you are dead on, this mission uses the same location as the LGB and dumb bomb training missions. As usual, there are a couple of enemy flights around, but if you set your EMCON state to 1 and do not take too long to accomplish your task, they should leave you alone.

On the other hand, you will usually get quite a bit of help from the other allied aircraft around. About 10 miles in front of you will be a flight of two F/A-18Es, attacking the same targets you should take out. Normally, their pass results in the destruction of all the Bedford trucks, leaving you just the fueltankers to play with. To make sure that your wingman does not blow them up before you have a chance to drop your bombs, order your wingman to attack the incoming MiG-27s. Next step is to select the Cluster Bombs as your active weapon, to build a shoot list and to use the up-front display to toggle through the targets until you have a fueltanker selected as your target.

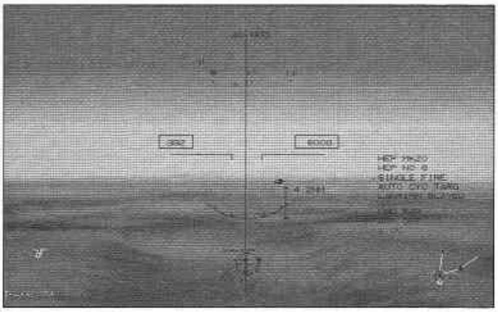


Figure 28

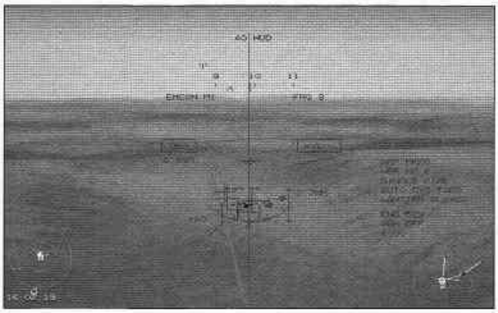


Figure 29

With the preliminaries out of the way, let us re-focus on the mission objectives. In order to achieve a reasonable distribution of the cluster bomb's submunitions, the cluster bombs in F-22 should be dropped in a shallow dive with a dive angle between 5-15 degrees. Due to a bug in the initial release of ADF, the cluster bombs split open after a certain time had elapsed, and the bombs had therefore to be released at an altitude of at least 1,000 feet, if you released them below that altitude, the submunitions would not disperse. In the patched version of ADF and in TAW, the bombs will still disperse their deadly cargo if even you release them below 1,000 feet. Speaking of dispersal, though you could also release the cluster bombs from level flight, the submunitions will then spread over too large an area, reducing the chance of achieving a hit on the intended target. The dispersal pattern is also influenced by the speed you are flying at when you drop the cluster bomb - if you are flying significantly faster than 450 knots, the submunitions will not spread as wide as they would if you were slower.

To sum up, the best method for delivery is a shallow dive at a speed of about 400 knots, release altitude greater than 1,000 feet. With the dive angle and minimum release altitude more or less fixed, the remaining question now is when to initiate the dive from which altitude to have the CCIP marker cross the target before you are below the minimum release altitude. Basically, an exercise in trigonometry, though if you start from around 6,000 feet when you are about 4 miles from the target, you should do fine (Figure 28).

Push the nose over until you are at a dive angle of around 10 degrees (Figure 29).

Your flight path marker should rest a bit above the target, if you point it directly at the target, the release marker will not cross over the target before you are below the minimum altitude of 1,000 feet. Now, the only things left to do are to keep the bomb fall line on the target, to wait until the release marker crosses the target and to release the bomb when it does.

Part II Advanced A2G Combat

Though the lessons of the Basic A2G Combat Chapter will have given you a solid foundation to solve the problem of tackling ground targets in F-22, there are still a number of useful tactics we have not mentioned so far. The reason was that the basic lessons should be just that - exercises where you learn the fundamental operation of your aircraft's weapon systems. Until the switchology has become second nature to you, it does not make much sense to embark on the advanced course, and if you do not feel completely comfortable in using the weapons we will employ in the advanced missions, I would suggest that you run through the appropriate basic mission once more.

The first advanced lessons will improve your ability to deliver a large amount of ordnance on the target - we will look at some alternate methods to deliver bombs. Although the two procedures you have learned in the basic section, level and shallow dive releases, are adequate to put steel on the target, there are ways to improve the accuracy and to keep you further out of the reach of the enemy's air defences.

Toss Bombing

One of the disadvantages of both level and diving bomb deliveries is the fact that you have to fly very close to your target to drop your bombs, in most cases, you will even have to overfly it (Figure 30). Since all valuable targets tend to be heavily defended, this is not exactly a safe way to do business. An alternative is to release the bomb while you are in a climb, and literally toss it towards the target. When you release the bomb in this manner, it will actually continue to climb above the release altitude before it starts its descent back towards the

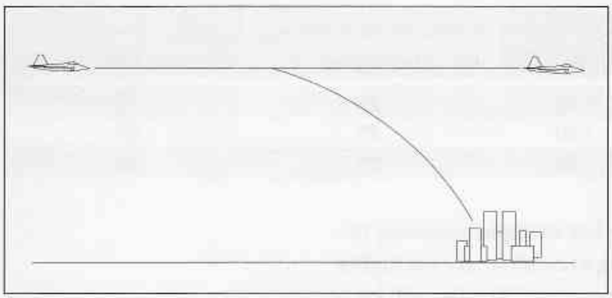


Figure 30 - Level Release

target. This extends a bomb's range and frees the launching aircraft from the hazardous duty of getting too close to the enemy air defences (Figure 31).

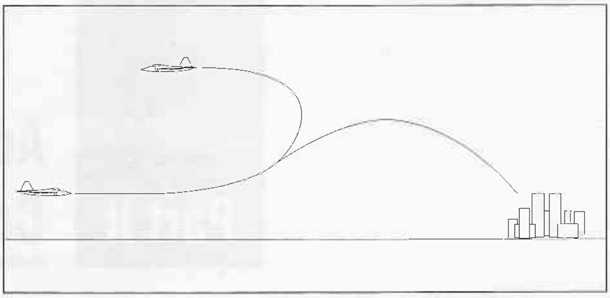


Figure 31 - Toss Release

Looks and sounds like a great idea to stay out of trouble, does it not? Well, it is. Why, you may ask now, are not all bombs delivered in this manner? Because it usually takes a very advanced weapons computer to calculate the bomb's flight path and to give the necessary cues to the pilot for both the pull-up manoeuvre and the bomb release in order to hit the target, since even the smallest errors in the climb angle or point of release will lead to huge misses. That kind of special computer is, even today, usually reserved for special-purpose aircraft like the Tornado, even the F-22 weapons computer comes without this mode.

However, with the JDAM, a bomb that already knows where it has to go, it is just a matter of releasing it within gliding range of the target to achieve a hit. Although the JDAM bomb can glide quite a bit even when released from level flight, releasing it while you are in a climb will extend its range considerably. As already mentioned, the F-22 weapons computer lacks the necessary 'smarts' to calculate the parameters for this bombing mode, it does not take the range extension achieved by the toss into account. Thus, the ellipse displayed on the attack MFD represents the distance the bomb would glide if it was released from level flight at the current altitude and speed. It therefore does not help us at all to determine when the target is in range, and the real toss ranges are a matter of trial and error, but due to the reduced danger, well worth finding out.

The following table gives a few examples of the achieved glide ranges for the indicated release parameters (for all examples, the pull-up was initiated at an altitude of 2,000 feet).

JDAM Toss Release Glide Distances

Pull-up Distance in Miles	Release Altitude In Feet	Release Speed In Mach	Climb Angle at Release In Degrees	JDAM Glide Distance In Miles
25	14000	1.50	25	20
32	21500	1.50	25	25
45	46000	1.40	25	30

With a glide distance of 30 miles for the last example, initiating the pull-up manoeuvre even further and trying to climb to an even higher altitude would not make much sense, a distance of 30 miles will keep you well away from any defences deployed at the target.

With the theoretical facts all laid down - and hopefully well understood, it is time to apply the newly acquired knowledge. To practice Toss Bombing, we will re-fly the JDAM interdiction weapons training mission.

Mission 1

Toss Bomb Release

Mission Target

Air Defence Headquarters

Flying the Mission

Although the briefing for this mission advises you to complete your approach at low level and to pop-up to release your weapon, the mission set-up is really ill-suited for this purpose, since you are almost on top of your target and just a few miles shy of the release point.

Since we want to practise a more realistic approach and toss release, the first thing we need to do is to put some distance between us and the target and to get down on the deck. Therefore, as soon as you hit the cockpit, set the EMCON state to 1, turn towards a heading of 135 degrees and push the nose over to initiate a descent to 2,000 feet. On the way down, select the JDAM as your active weapon to get an accurate range readout of your distance to the target. Level out at 2,000 feet and extend until you are about 30 miles from the target. If you are easily bored, use the time-acceleration, **SHIFT - T** to speed things up.

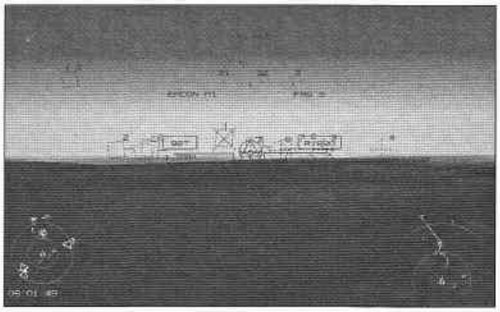


Figure 32

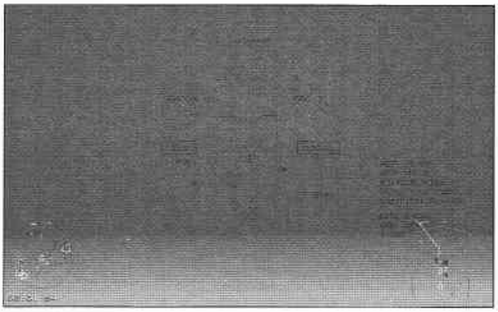


Figure 33

When you are at least 30 miles from the target, turn around until you are pointing directly at the target, level out and shove the throttle up to full afterburner. When you are 25 miles from the target, pull the stick gently back until you have achieved a climb angle of 25 degrees (Figures 32 and 33).

The reason why you should pull the stick gently back is that you will apply less G and you will therefore lose less speed as opposed to just yanking the stick violently back.

Concentrate on maintaining the 25 degree climb whilst keeping the crossed target symbol in line with your flight path marker, thus ensuring that you continue to fly directly towards your target. When the distance readout has run down to 20.0 miles, release the JDAM, pull the throttle back to

full military power and execute another 180 degree turn. When you are finished with this and are safely established on your way home, switch to the missile view to watch the JDAM finish the task.

Dive Bombing

Although we have already used diving approaches during the Basic A2G combat training missions, there is still a bit more to be known about dive bombing. The shallow dive angles we have used so far are pretty useful if you have trouble lining up with the target, since the target will be in your field of view for a comparatively long period of time before the CCIP marker comes into view. However, once it comes into view, it tends to pass over the target rather quickly, and you have to time the weapon's release pretty good (Figure 34).

If you tend to get either long or short rounds regularly, you might want to take a closer look at diving attacks with a medium dive angle - between 30 and 55 degrees. For a given aircraft speed, you will trade time to line up for a slower 'CCIP- marker -target crossing-speed'. The reason for this lies in the fact that your speed, in contrast to level flight, gets split up into a horizontal and a vertical component (Figure 35).

With your vertical speed component increasing the steeper the dive angle becomes, the horizontal component will decrease accordingly, thus reducing the speed with which the CCIP marker crosses the target. In the most extreme case, a vertical dive, the CCIP marker would come to rest on the target.

However, diving attacks with large dive angles are not without problems.

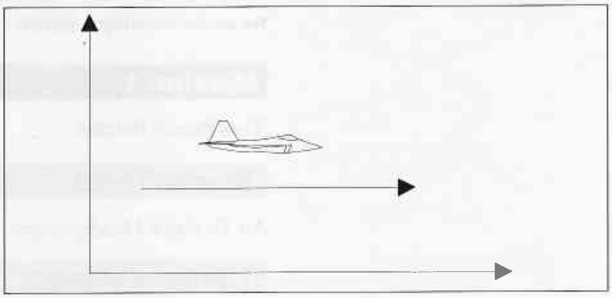


Figure 34

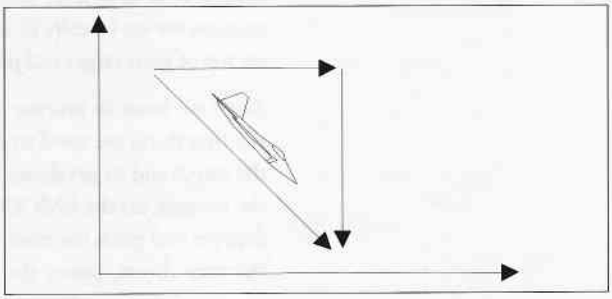
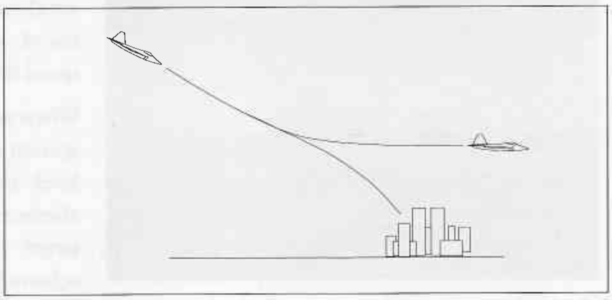
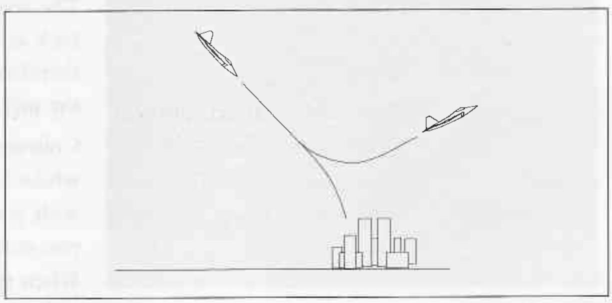


Figure 35



Shallow Dive



Steep Dive

In order to attack with a higher dive angle from a given altitude, a medium angle dive attack will always have to be initiated closer to a target than a level bomb run or a shallow angle dive attack. Thus, even though you reduce the risk of long/short rounds, you will have less time to line up on the target. Still, it is not such a big problem since you can compensate this by approaching the target at a higher altitude. But even if you start from a high altitude, this time becomes so short for steep diving angles (>60 degrees) that hitting the target becomes very difficult.

As with the Toss Bombing, it is now time to apply the theory, and we will use the Bomb BAI weapons training mission to expand our knowledge.

Mission 2

Medium Angle Dive Attack

Mission Target

Warehouse

Flying the Mission

Since 10,000 feet is a bit low for our purposes, advance the throttle to full afterburner and pull up into a 25 degree climb as soon as you hit the cockpit. Select the Mk 82F as your active weapon, go down to the Systems MFD and set the fire mode to 'Salvo' and the firing number to 4, just as before. When we flew this mission in the Basic A/G Training Chapter, we approached the target at 20,000 feet. Whilst this would be a good occasion to demonstrate by how much the distance at which the dive must be initiated is reduced by the use of a steeper dive angle, we will the nevertheless approach the target at the higher altitude of 25,000 feet. We will do this for two reasons. First, it will give us more time to correct line-up errors during the dive. The second reason is that we want to keep above the AAA engagement altitude of 6,500 feet, and if we would initiate our attack from 20,000 feet, it is very likely that we would get below that altitude.

Therefore, level out at 25,000 feet and make sure you are still heading directly towards the target. Since the target is exactly at waypoint 2, it is just a matter of keeping the waypoint caret precisely centred. When you are 4 miles from the target, pull the throttle back to idle, roll the aircraft through 180 degrees, pull back sharply on the stick until the flight path marker is about 5 degrees below the target, roll the plane right side up again and extend the airbrake.

In case you are wondering why we used the roll-pull-roll procedure to initiate the dive – it is quicker. The F-22 can handle positive G-forces up to 9.5, whereas it is limited to –3.5 on the negative side of the scale. Thus, you can pull the nose through many more degrees per second

than you can push it. Consequently, larger downward flight path changes should always be executed with the roll-pull-roll method. The reason why you should pull on the stick until the plane is pointing below the target is to give you some pull-up margin to correct line up errors before your dive angle becomes to shallow.

With the plane upright again, correct your line-up. Once the bomb-fall line runs straight through the target, pull the nose up until your flight path marker rests about five degrees above the target (Figure 36).

Now it is just a matter of waiting for the CCIP marker to cross the target, as you can see in Figure 37.

If things look like above, release the bombs, pull the stick back, retract the airbrake and advance the throttle to full afterburner. Note that the release altitude in this example is 7,000 feet, leaving you a large enough margin to bottom out above the AAA engagement altitude of 6,500 feet.

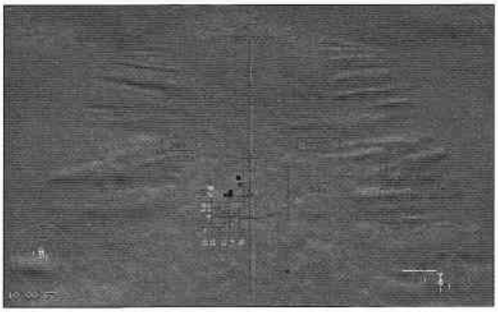


Figure 36

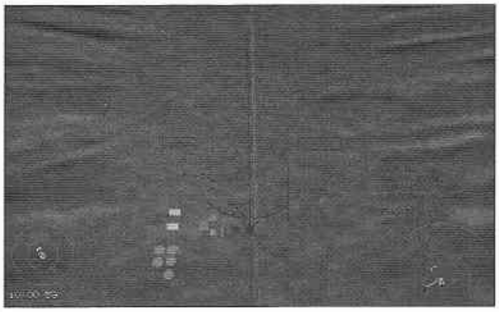


Figure 37

Part III Re-Attack

In reality it is usually a dumb, if not downright suicidal idea to attack a heavily defended target more than once (aka. 'One pass - haul ass'). The enemy defences will have been alerted by the first pass and the enemy gunners will probably be rather annoyed at having failed to shoot down the attacking aircraft at the first opportunity. Thus, they will be highly motivated to accomplish their task if they get a second chance, which is precisely the reason why real world pilots tend heavily towards not granting them that opportunity.

In F-22, however, it will sometimes be unavoidable to attack a target more than once. For instance, there are a couple of missions where it will be impossible to hit all the mission objectives on one pass, necessitating at least a second and sometimes even more runs at the target(s). There is also the chance that you will actually manage to miss the target once in a while (admittedly rather small if you diligently worked through the preceding chapter).

The good news in this context is that the dangers of conducting numerous attacks in F-22 are not quite as great as in reality. First, there will be no discernible difference in the enemy reaction compared to your first run. The computer gunners are always wide awake, and if you managed to survive the first pass, you are obviously good enough to have a reasonable chance of surviving a couple more passes. Even if it does not work out quite that way, you only loose a bit of your pride, not your life.

Nevertheless, the re-attacks should be conducted as fast and as efficiently as possible. Sometimes, there are enemy interceptors inbound which will make a prolonged stay an unhealthy proposition. Even if the danger level remains the same throughout the attack, it is still advisable to conclude your business with the least possible number of passes, since even a statistical chance of being hit of just 5 percent adds up to near certainty if you need too many passes.

In this section, we will therefore introduce a couple of manoeuvres which will help you to bear down on your target again in the shortest possible time, within the parameters necessary for a successful deployment of your selected weapon.

Mission 3

Half-Loop Reversal

Mission Briefing

The Half-Loop Reversal is used to conduct repeated, medium angle diving attacks on the same or closely spaced targets. Figure 38 shows how the Half-Loop Reversal is used to achieve the ideal position for a re-attack.

Flying the Mission

For this mission, we will again use the Bomb BAI weapons training mission. Since we want to practice re-attacks for medium angle dives, we will approach the target again at 25,000 feet and execute the first dive just as outlined in the respective mission run-through, dive initiation at 4 miles from the target, dive angle about 45 degrees, weapon release and pullout above the AAA engagement altitude of 6,500 feet. If the enemy fighters become a nuisance, order your wingman to engage them.

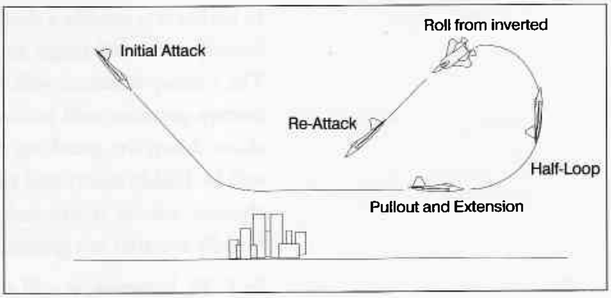


Figure 38
Half -Loop Reversal (side view)

At this point, we will deviate from the old script. Instead of continuing the pullout until you are climbing again, stop to pull back on the stick when you are flying level again. If you have not done so already, retract the airbrake and advance the throttle to full afterburner, you need to pick up some smash to end up with a reasonable and useful speed at the top of the half-loop. How far you extend is basically determined by how precise you can fly the half-loop.

If you are (or have become) pretty good at it, you only need to extend for about 4 miles, since this is the distance at which the dive should be initiated. However, if your half-looping is not quite exact yet, add two or three more miles to your extension (Figure 39), you can use that distance to correct gross line-up and/or altitude deviations at the top before you commence your attack again.

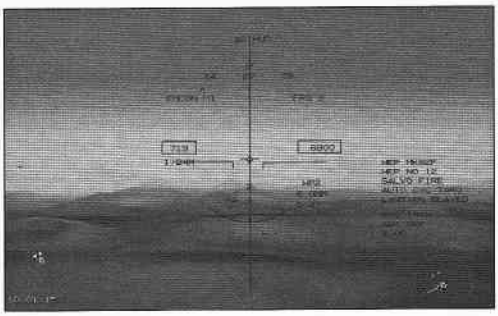


Figure 39

Irrespective at which distance from the target you initiate it, keep in mind that the half-loop is not only used to reverse the direction, we also need to gain between 17,000-20,000 feet of altitude while we are executing it.

To achieve the second goal, you should resist the temptation to pull the stick fully back and to fly a Max-G half-loop, which will result in an altitude

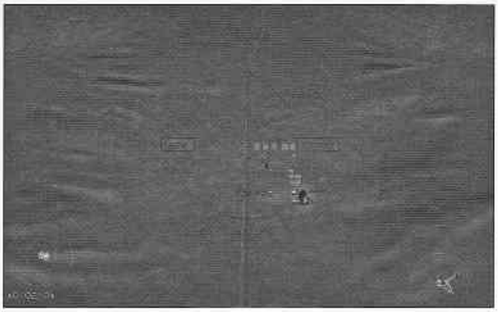


Figure 40

gain of a mere 9,000-10,000 feet. Instead, perform a nice and easy 4.0-4.5G half-loop to gain the desired altitude. When in doubt, apply initially less G rather than more, since it is better to tighten the loop when you reckon you will overshoot the desired altitude instead of widening it out at the top. In the former case, you will end up at the desired altitude a bit further from the target than you were when you initiated the half-loop, in the latter, you will end up closer to the target, and if you started the loop at the minimum extension distance to begin with, you can basically forget this approach.

But let us assume everything is going according to plan and you have reached an altitude of around 25,000 feet. If you fall into the hot-shot category and have begun the half-loop at the minimum extension distance of 4 miles, do not roll the plane right side up again. Pray that you have not attained large line-up deviations during the loop, pull the stick full back until your nose is pointing below the target and commence your attack.

For the more prudent flyers, roll the plane right side up again and correct any existing line-up/altitude deviations. When you reach the 4 mile target distance again, roll the plane inverted, pull back on the stick until the nose is pointing below the target and you are ready to wreak havoc again.

If you have missed the primary target with your first bombs, you are already set up perfectly to re-attack it again (Figure 40).

However, you if you scored a bullseye, line-up one of the remaining buildings and have a go at the new target.

Mission 4

Split-S Reversal

Mission Briefing

The Split-S Reversal is a manoeuvre to quickly reverse the direction for repeated shallow angle dive attacks whilst staying on the same bearing line. The latter attribute makes it a very useful manoeuvre if you have to make repeated passes at moving vehicles or ships (Figure 41).

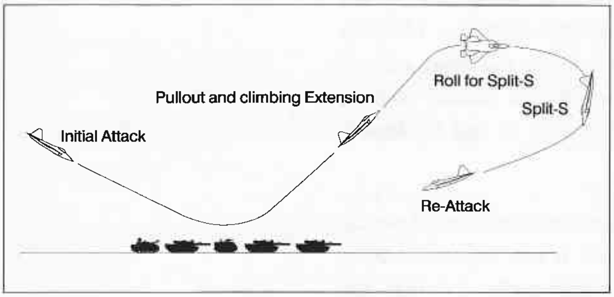


Figure 41 - Split-S Reversal (side view)

Flying the Mission

To practice the Split-S Reversal, we will refly the Cluster CAS weapons training mission. However, we will

target the tank, which is sitting smack in the middle of the road running through the target area instead of the original mission objectives, the Fuel Tankers and the Bedford trucks. In order to ensure that our wingman will not interfere with the training, wait until he has called out the two MiG-27s and order him to engage the bandits.

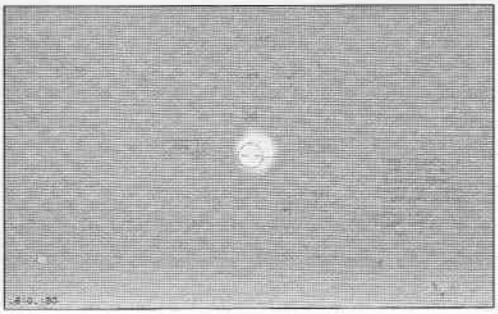


Figure 42

After you have dispatched him, descend to 3,000 feet and align your flight path with the long straight stretch of road on the right side of the target area. Select the cannon as your active weapon, build a shoot-list and toggle through it until the tank appears on your up-front display. When you are 3 miles from the target, commence your attack. Throttle back to idle and push the nose down until the piper rests below the target. When the range clock has run down to the six o'clock position, pull the piper onto the target. Since we only have that one practice target left, we will have to keep it to have something to make the re-attack worth the while, so do not actually shot at it, just continue your approach as if you were executing a real attack. When your altitude approaches 300 feet, start the pullout. Advance the throttle to full afterburner and pull up into a 30 degree climb (Figure 42).

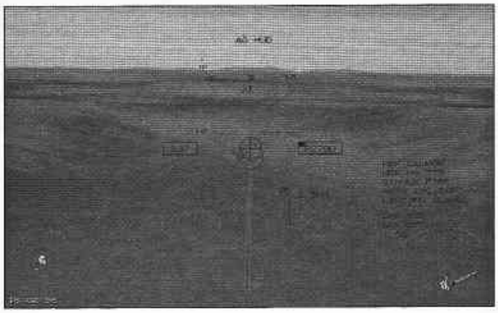


Figure 43

Continue to climb straight away until you have reached an altitude of 4,500 feet. At this altitude, chop the throttle back to idle and roll the plane through 180 degrees. At this point, it is very important that you roll the plane through as exactly 180 degrees as you can manage, if you are off by more than 4 or 5 degrees, the subsequent Split-S will introduce a considerable line-up deviation.

Assuming that you performed a (near) perfect half-roll, extend the airbrake and pull the stick fully back to initiate the Split-S. At this point, you should be at an altitude between 5,300-5,500 feet. Hold the stick back until the piper is pointing slightly below the target again. If everything went according to plan, your altitude should now be around 3,000 feet and your dive angle between 10 and 15 degrees (Figure 43).

As you can see, the Split-S reversal puts you back into a letter-perfect position for another strafing run at the tank. If you look at the street (our imaginary bearing line) you can also easily see that this manoeuvre will keep you nicely aligned to a convoy's line of travel.

Mission 5

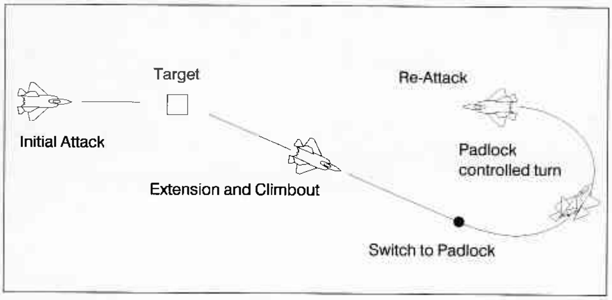
Slice-Reversal

Mission Briefing

If your approach to simulation-flying is a bit more 'hands-on' than cranial, the number-flying of the preceding mission is probably not quite your cup of tea. An alternate method to initiate a re-attack for shallow dive angles is the Slice-Reversal (Figure 44). It still requires you to take a few numbers into account (sorry 'bout that), but it relies on the Target Padlock View for the decisive phase of manoeuvring.

Flying the Mission

Figure 44
Slice-Reversal (Top View)



Since it is still us against Ground Mobiles, we will use the Cluster CAS weapons training mission once again. Up to the end of the initial dive, we will follow the procedures used in the preceding mission - dispatch wingman to go after bandits, descend to 3,000 feet, use road for alignment, select cannon and so forth. Please refer to the preceding mission run-through if you are in doubt as to how to handle the initial attack.

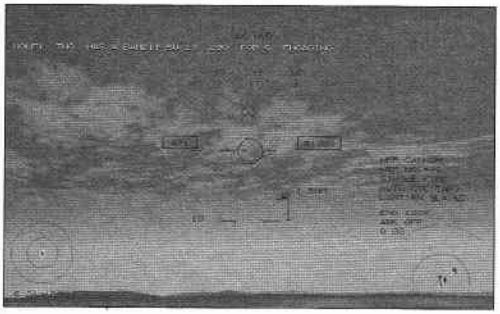


Figure 45

After the first dive, change course by roughly 20 degrees, either left or right, and pull up into a 20 degree climb (Figure 45).

When you have reached 3,000 feet, roll the plane until you are in 100 degree bank back towards the target. At this point, you are done with the numbers for this manoeuvre and can switch to the Target Padlock View (Figure 46).

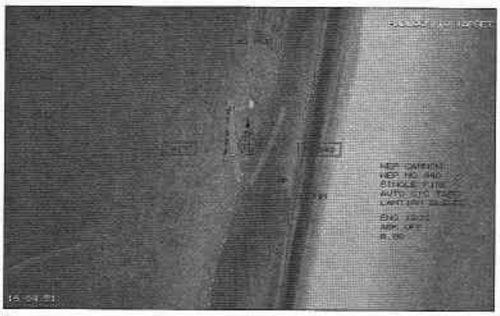


Figure 46

Since you are now concentrating on the Padlock View, let us have a mental look at what happens when you start to pull back on the stick. Your plane's nose is still pointing above the horizon, but due to the 100 degree bank angle, your lift vector is already pointing back towards the earth. Starting with those parameters, your plane's nose will literally slice diagonally across the sky during the turn (hence the manoeuvre's name) until you are pointing back towards the target and roll out of the Figure 47).

Your main task, after switching to the Target Padlock View and initiating the turn, is to watch the Target Padlock View's motion towards the pointy end of your plane. Try to time its arrival there so that you are also aligned with the road when the Padlock View has rotated towards the front. You can adjust your plane's turn rate, and hence the speed with which the Target Padlock View rotates back towards the front by increasing or decreasing the back pressure on your stick.

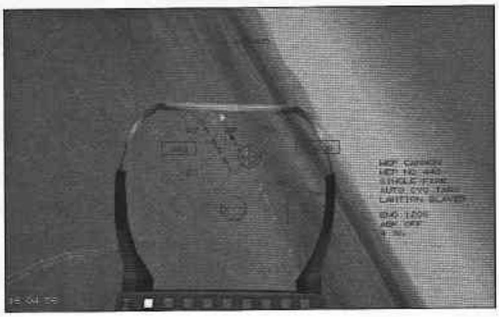


Figure 47

This probably sounds a bit complicated now. However, once you are in the cockpit and can see how the turn rate changes according to the changing back pressure on the stick, you will have no trouble at all to figure out how to adjust your turn so that you roll out on the bearing line, ready for the next attack.

You may have noticed the numerous references to controlling the EMCON state manually and the constant setting of it to '1' (except for launching the radar-guided AIM-120). This is because experience has shown that letting the computer handle your electronic output is downright dangerous - it will more often get you into trouble than out of it or help you to avoid being detected in the first place.

The reason for this is that the AUTO EMCON control tends to react to the proximity of enemy threats by switching to an EMCON state of at least 4 in order to bring your defensive suite to full readiness. In theory, that would not be a bad thing. However, since your radar is also tied to the EMCON setting, EMCON 4 will also switch your radar to its highest output state. At this point, you are as inconspicuous as a dark-clad burglar stalking through the night, carrying an enormous, blindingly bright flashlight in his hand. All advantages the stealthy

EMCON Setting	Throttle Setting	Detection Range at 'HARD' Difficulty	Detection Range at 'MEDIUM' Difficulty	Detection Range at 'EASY' Difficulty
1	Idle	4.5	4.0	2.0
1	Full Afterburner	7.0	7.0	4.0
2	Idle	8.0	7.0	3.5
2	Full Afterburner	13.0	11.5	6.0
3	Idle	8.5	7.5	4.0
3	Full Afterburner	14.0	12.5	6.5
4	Idle	9.5	8.0	4.5
4	Full Afterburner	15.5	14.0	8.0
5	Idle	10.0	9.5	5.0
5	Full Afterburner	17.0	14.5	9.5

design of your aircraft should give you are gone immediately. The following table shows you just how much the higher EMCON states increase your detectability and hence, your vulnerability. The distances were determined by annoying an SA-6 SAM launcher and are given for an altitude of 10,000 feet, 90 degree bank angle (worst case) and full external stores (worst case as well).

Although the exact distances are different for other enemy ground-based or airborne hardware, the relative changes still apply, and as you can see, EMCON 1 reduces the range at which the enemy can detect you by more than 50 percent compared to EMCON 5. You should also note (and keep in mind) that cutting the throttle reduces the detection distance significantly as well.

If you are flying at the 'Hard' level, your options to avoid getting hit are pretty limited once a SAM has been launched at you. Although keeping it at your 10 or 2 o'clock and breaking towards and under it when it is at about 2-3 miles away whilst pumping out chaff works sometimes, it is by no means a sure thing, you will probably get hit as often as not. On the medium and easy level, flying perpendicular to the missile and chaffing very liberally tends to work sometimes as well.

Although real world SAMs are generally of the semi-active type and the launcher therefore needs to keep you locked up until the missile hits you, unfortunately breaking the radar lock does not work in F-22. The SAMs have the same acquisition characteristics of their air launched cousins, with the seeker head on the missile rather than on the launching vehicle.

The only 100 percent working solution to defeat a SAM on its way is to manoeuvre in such a way that you get a solid piece of earth between you and the missile, and even that only works when you have been pretty close to the ground to begin with. If you were at an altitude of more than 8,000-10,000 feet when the missile was launched at you, the missile will have gained so much altitude during the time you were manoeuvring that it will enjoy an unblockable view at you by the time you are hugging the mountains.

However, since the ground hugging option is not always available, the safest way to defeat a SAM is to deny the launching platform the lock it needs to fire at you. Your personal survival is as good as guaranteed if you stay at EMCON 1 and use the Defence MFD to plot a course that keeps you outside the engagement ranges. Unfortunately, there is no way to order your wingmen to stay at EMCON 1, they will fly under AUTO EMCON all the time. Therefore, if you are shepherding a

couple of those guys around, switch to EMCON 4 once in a while when you are approaching enemy defences to get an idea how wide you have to detour to keep your wingmen out of the line of fire as well.

In those cases in which it is necessary to attack targets defended by SAMs and AAA, you will usually have a sufficient number of long range weapons distributed amongst the strike package to take out those defences before you have to go in to mop up.

But if you manage to lose some or all of your wingmen on the way in, you have to defeat the missile threat with other means. In the final mission run-through of this chapter, we will learn how to accomplish this.

Mission 6

Wild Weasel (The hard way)

Mission Briefing

In this mission, we will hunt and defeat SAMs and AAA in the same way the very first Weasel crews did it in Vietnam, with Cluster Bombs, unguided rockets and lots of guts. Their flight suits were decorated with the stitched 'YGTBSM' line for a reason - you do not have to be crazy to do this, but it will certainly help.

For this hop, we will, once again, refly the Cluster CAS mission, but we will ignore the primary target completely this time. When you enter the mission, turn towards a heading of 195, select the AIM-120 as your active weapon and get ready two kill the two MiG-27s coming your way. When they are in range, fire all your AIM-120s at them and order your wingman to engage them as well, there are no other airborne threats out there with whom you would have to concern yourself and hence, there is no need to save missiles.

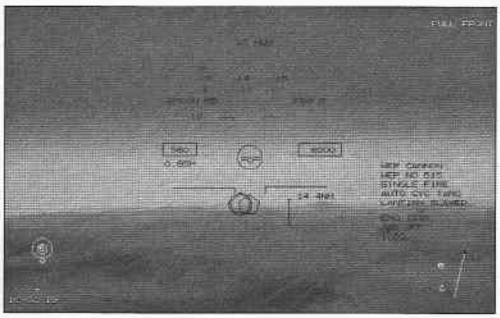


Figure 48

By the time you have dispatched the two MiGs, the Air Defence formation we want to kill (consisting of two SA-6 SAM launchers and one ZSU-23/4 AAA vehicle) should be at a bearing of 130 degrees, a bit left of your way home. Select the cannon as your active weapon, build a shootlist and select one of the SA-6 SAM launchers as your target to get the range information. Descend to 6,000 feet, keep your speed between 500 and 600 knots and set your EMCON state to 5, since you want them to notice you.

On your way to the target, watch out for a road running more or less perpendicular to your flight path, although you are in an aircraft, we will use that road in the upcoming evolution (Figure 48).

In order to get close enough to the enemy air defences to kill them with our short-ranged weapons, we will take advantage of the fact that the enemy missile launchers can and will run out of missiles eventually. We will present ourselves as inviting targets, defeat the missiles launched at us and close in for the kill once the long range threat no longer exists.

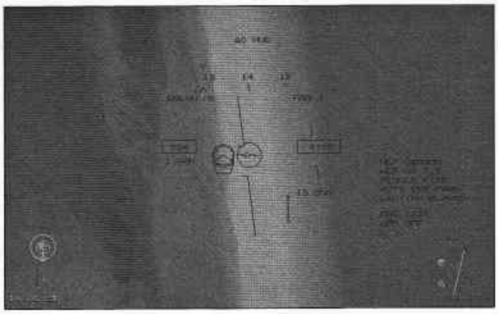


Figure 49

When you are about 15 miles from the target, it is time to provoke some reaction from the enemy. As you have seen in Figure 41, the road should be almost beneath you at this point. The general idea is to get shot at now and then immediately dive down into the small valley through which the road runs.

In case they have not shot at you already, roll the plane until you are at a bank angle of 90 degrees, you will be even less stealthy that way and the enemy will certainly accept the challenge (Figure 49).

With the missile on its way, continue the roll until you are inverted and pull the stick back to get down into the valley as quickly as possible, the missile should lose its lock as soon as you reach the valley floor. Once the threat has been defeated, switch to EMCON 1, and start a left climbing turn out of the valley. Climb to 6,000 feet and continue to fly on a heading of 330 degrees until you are at least 20 miles away from the SAM launchers. When you have reached the required distance, turn back towards the enemy, switch to EMCON 5 again and repeat the above procedure.

Eventually, you will not get shot at again. To make sure the enemy really has no missiles left, check both launchers on the up-front display to confirm the launch rails are empty.

If they are, it is time to go on the offensive. The remaining problem now is the ZSU-23/4 AAA vehicle. Of the A2G weapons you have on board, the cannon is definitely the least effective due to its short range. By the time you are in effective cannon range, the ZSU's guns will be as well, and they are very, very lethal. It will also be a bit difficult to aim the cannon, since ADF units are represented as pentagons instead of crosses, and it is a not quite easy to precisely aim at the middle of that. The LAU-68 rockets, though being longer ranged than the cannon, basically suffer from the same aiming problem. With the cluster bombs, precision is not quite that important. However, our standard, shallow diving release, would lead us too close to the ZSU's guns, and medium angle diving attack is not feasible for the same reason. Hence, we have to conduct a diving attack with a rather steep dive angle between 60-70 degrees.

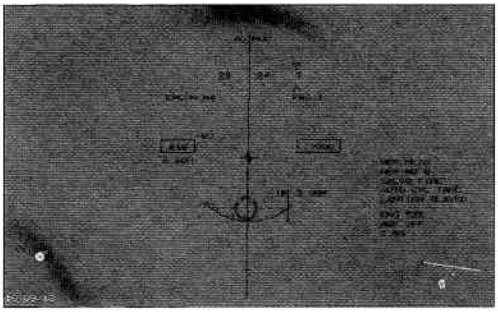


Figure 50

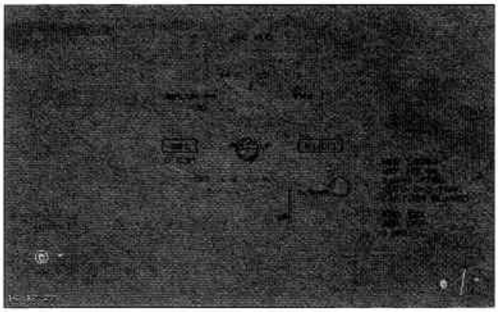


Figure 51

Set all this up whilst you are heading towards the target and climbing to 27,000 feet. When you are 3.5 miles from the target, invert the plane and pull the nose down until you have attained a dive angle of 70 degrees. Roll the plane right side up again, put the bomb fall line through the pentagon's centre and stabilise your dive. If the scene you are looking at looks like Figure 50, you are all set.

When the CCIP marker is in the middle of the pentagon, release your bombs and pull out of the dive. Usually, the ZSU will succumb to the three Mk 20s dropped on its head.

With the last threat out of the way, you can now dedicate a bit of your attention to the two empty SAM launchers. Since it would be foolish to leave them in perfect working order so that the enemy just has to reload them, it is time for some old-fashioned strafing again.

As already pointed out, the fact that ADF units are represented as pentagons makes lining up a bit difficult, coupled with the fact that they are deployed in the middle of the mountains requires you to give the run-in heading careful consideration. However, by now you should be an old pro in this business, and a bit of added challenge just keeps it interesting. Just align the piper very carefully with the centre of the pentagon, and when the launcher finally becomes visible, fire a short burst and pull up at once (Figure 51).

Though crashing on top of the launcher would certainly retire it, an ordinary re-attack is usually the easiest way to accomplish the task in case the first pass has not obliterated the target.

Set all this up while you are heading towards the target and climbing to 20,000 feet. When you are 5.5 miles from the target, invert the plane and pull the nose down until you have attained a dive angle of 70 degrees. Roll the plane right-side up again, put the bomb fall line through the pentagon's center and stabilize your dive. If the scene you are looking at looks like Figure 50, you are all set.

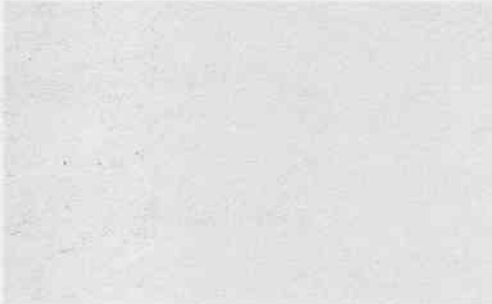


Figure 50

When the CCIP marker is in the middle of the pentagon, release your bombs and pull out of the dive. Usually, the ZSU will vanish as the three MK 82s dropped on its head.

With the last threat out of the way, you can now dedicate a lot of your attention to the two intact SAM launchers. Since it would be foolish to leave them in perfect working order so that the enemy just has to reload them, it is time for some old-fashioned strafing again.

Figure 51

As already pointed out, the fact that SAM launchers are represented as pentagon makes lining up a bit difficult, coupled with the fact that they are deployed in the middle of the [illegible] requires you to give the run-in heading careful consideration. However, by now you should be an old pro in this business--and a bit of added challenge just keeps it interesting. Just align the pipper very carefully with the center of the pentagon, and when the launcher finally becomes visible, fire a burst and pull up (Figure 51).

Though crashing on top of the launcher would certainly strike it, an ordinary reattack is usually the correct way to accomplish the task in case the first pass has not destroyed the target.

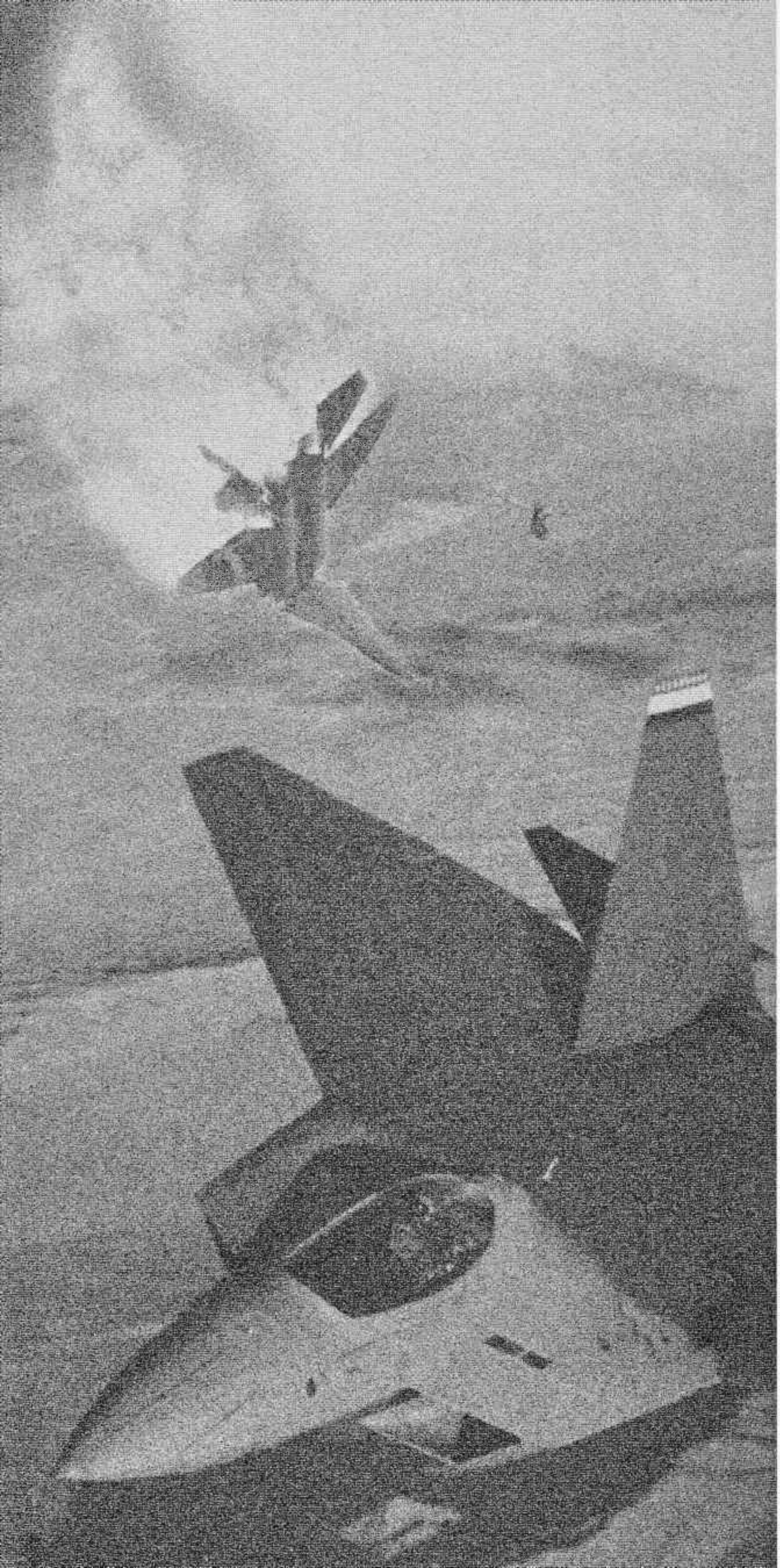
Chapter 8

THE TOD
COMPANION

RED SEA TOUR

ERITREA TOUR

YEMEN TOUR



CHAPTER 8

Chapter 8

The TOD Companion

In this chapter, we will take a closer look at the missions you will have to fly as part of the three original Tours of Duty. Although the missions are scripted, this does not necessarily mean the chain of events in the missions will always be the same. In fact, it is pretty unlikely. Due to the AI reacting to the player's actions and the randomness inherent in the weapon's performance, you might have to tackle a considerable enemy force all alone on one occasion whereas on the next run-through, allied flights and/or your wingmen might have already taken care of a good chunk of the threats. But even if other allied forces perform very well, you will usually find that enough work has been left for you, and the mission descriptions will help you to concentrate on the really important aspects of the missions.

By now, you should have become reasonably acquainted with your F-22, and therefore, the mission descriptions will be rather brief, concentrating on mission-related points.

Part I Red Sea Tour

Having acquired a significant amount of the latest U.S. military hardware during recent years, Egypt is now prepared to settle some old scores with Sudan. After the initial Egyptian moves, the U.S., with the help and co-operation of Saudi Arabian Forces, launch a number of pre-emptive and limited strikes to stop the Egyptian aggression before the conflict escalates into a full-blown war.

If you happen to have a split personality, you will really like this TOD. In the Red Sea Tour, you will find yourself on both sides of the line and the answer to the question 'Who are the baddies' will change with almost every mission you fly.

Mission 1

Prelude

Mission Type

Pre-Strike Reconnaissance

Mission Objectives

You must land at Abu Simbal Dispersal.

You must pass over waypoints 6 and 8.

Enemy 767 flight CARPET1 must not be destroyed.

Enemy 767 flight CARPET3 must not be destroyed.

Enemy ANT-70 flight AL_JUMA2 must not be destroyed.

Mission Description

With a little caution, this 'go over there, have a look and stay out of trouble' kind of mission is really a milk run to ease you into the first TOD. When you enter the cockpit, you are already pretty close to the first of the two fly-over-waypoints. Due to the stealth characteristics of your plane and a careful interpretation of the Rules of Engagement (ROE), it should not be a problem to stay out of trouble for the rest of the mission.

When you set your EMCON state to 1, the flight up to waypoint 8 will be pretty uneventful. However, at and around waypoint 8, there are a

couple of enemy air defence units deployed and a lone Su-27. At this point, you should note that neither the ROE nor the mission objectives say anything about leaving the air defences or the Su-27 alone, it is time use your weapons to eliminate the threats. Usually, you should have enough time to take out the air defences first. As you pass waypoint 7 and turn towards waypoint 8, select the Mavericks as your active weapons, build a shoot list and plain and simply destroy the SAM launcher and the ZSU-23. You might have to either decelerate or turn away to give the Mavericks a chance to destroy the targets before you fly into the engagement envelope. Next step, take out the Su-27 whilst keeping away from the airfield's air defences. With the immediate threats out of the way, the rest of the flight should be pretty uneventful except for making a couple of turns to stay out of the range of the occasional air defences.

Mission 2

Close Hostile

Mission Type

Escort

Mission Objectives

You must land at Yanbu al Bar.

Enemy Rafale flight TIGER1 must be destroyed.

Enemy Rafale flight TIGER4 must be destroyed.

Enemy F-16U flight SITTA1 must be destroyed.

Allied flight ANT-70 AL_JUMA2 must not be destroyed.

Mission Description

In this mission, your task is to see that the ANT-70 has a safe and uneventful journey. Unfortunately, the enemy is pretty much bent on taking it out, you will have to kill the three flights mentioned in the briefing before they have a chance to fire at the Antonov, since it will usually fall to the very first missile.

Therefore, go to full burner as soon as you hit the cockpit to get ahead of the ANT-70. The action will take place at or beyond WP2, so you need to get there as fast as possible. The three enemy flights are spaced out far enough to make it possible to be finished with the current threat before the next comes into missile range.

However, you do not have time to waste, and you cannot allow an enemy fighter to get past you and take a pot-shot at the transport plane. Thus, serve the enemy planes always a double helping of A2A missiles, order your wingman to engage and as soon as you see that he has fired on all targets, fire a missile at each yourself. You can allow yourself and your wingman to waste all your missiles on the two

RAFALE flights, the F-16Us are only armed with guns and can be dealt with at close range.

Mission 3

Bill's Limo

Mission Type

Scramble

Mission Objectives

Enemy flight Su-30 HARBIN1 must be destroyed.

Enemy flight Su-30 HARBIN2 must be destroyed.

Enemy flight Su-35 ZHUOZI1 must be destroyed.

The Limo and the Learjet AMBER1 must not be destroyed.

Mission Description

Although it is only a short mission, it is also rather difficult. Unfortunately, it is pretty much dependent on how well your missiles work, which will probably necessitate several reflights at the 'Hard' level.

After you hit the cockpit, you have about 60 seconds to kill the first group of Su-30s, and only a bit longer for the second group. Therefore, go to full burner immediately, take-off and turn right to engage them. Order your wingman to engage and get down to killing the flights as fast as possible. The Su-30s should be your first priority, as they will hit the targets on the ground and can attack them immediately, the Su-35s will at least have to wait until the Learjet is airborne. Due to the close range, there is really no point in trying any fancy manoeuvres, either your missiles perform well or you will lose the mission.

Mission 4

Arabian Sword

Mission Type

Fleet Defence

Mission Objectives

The three allied Type23 destroyers must not be destroyed.

You must land at Mecca.

Mission Description

Looking at the Situational MFD when you hit the cockpit, this mission probably appears a bit intimidating. The display will be filled with quite a number of enemy aircraft. However, the mission's success or failure is not tied to killing as many enemy fighters as

possible, you must only make sure that the destroyers survive. Which, in turn, leads us to the question 'Which fighters pose a threat to those ships'? Well, only one group of aircraft represent a danger to the ships, the F/A-18Es.

The natural impulse would now be to charge forward and to try to kill them as far away from the ships as possible. Understandable, but quite wrong, because you would get much too close to all the other enemy fighters if you did that.

Instead, continue on your course until you are above the destroyers and settle into a slow orbit. As you will see, the F/A-18s and their escort, four F-14s, will be the only planes to come forward. At about 50 miles from the ships, the F-14s will split up and start to look for enemy fighters. During their search, they will actually reverse course and open a gap through which the F/A-18s will pass and into which you can attack. Engage the F/A -18s yourself and order your wingman to engage the escort. Once the F/A-18s are destroyed, do not linger, get out of there as fast as possible.

Mission 5

Strike Sudan

Mission Type

Strategic Bombing

Mission Objectives

Multistory office building must be destroyed.

You must land at Wadi Halfa.

Mission Description

This will be the first incursion into enemy territory where shooting is not an option but the whole point of the exercise – Egypt finally drops all pretence and goes to war. You will be part of a massive strike package of 3 flights of four F-22s accompanied by a 4-ship EF2000 Wild Weasel flight and a 4-ship EF2000 Escort.

In those numbers lies safety, and compared to the previous missions, your secondary workload will be significantly reduced and you can concentrate on the primary mission. Although you will be faced with numerous enemy interceptors and SAM defences, the other flights will generally be able to deal with all the threats along the way. You can still join the shooting if you want to, but it is an option, not a necessity.

For the ingress, stay in formation and let the other guys do all the hard work. When you have passed the fourth waypoint, climb to an altitude of at least 20,000 feet to have sufficient altitude for the attack on the office building. Since you will have to destroy it with dumb bombs, a dive attack will be the best way to deal with it.

Mission 6

SAMs

Mission Type

Wild Weasel

Mission Objectives

You must destroy 2 SA-6 and 2 SA-11 launchers.

You must land at Yanbu al Bar.

Mission Description

This and the next mission are part of a commando raid to liberate a captured merchant ship. In this mission you are tasked to clear the way for the following helicopter flights by eliminating the enemy's long range air defences. As if this was not already dangerous enough, it is also a night mission. However, there are two types of nights in F-22, pitch-black and moonlit. If you do not feel quite comfortable to fly completely on instruments or with the use of the night vision devices, I would suggest that you restart the mission until you get a full moon.

Apart from the night part, this mission is, again, pretty doable. You can pretty much dash in, kill the targets and be gone before somebody notices that you have been there. The only difficulty is to make sure that you hit the right targets and do not waste your missiles on air defence units that should not concern you.

To make sure you kill the right targets, fly straight on after you have passed waypoint 3, your targets are defending the airfield beyond the waypoint and are all within the red killboxes. Build a shoot list, order your wingman to engage and start your own run. Toggle through the targets until have the missile launchers selected, there is no sense in wasting those expensive HARM missiles on mere AAA vehicles. At night, the up-front display is not quite sufficient to discriminate between the different types of targets, you might have to go down to the ATTACK MFD and switch the IR view on to get a picture clear enough for positive identification.

Mission 7

Fighters

Mission Type

Escort

Mission Objectives

Allied Flight JOLLY 1 BLACKHAWK must not be destroyed.

Enemy F-16 flight BLADE1 must be destroyed.

Enemy F-14 flight BLACKACE1 must be destroyed.

Enemy A-10 flight BEAST1 must be destroyed.

Mission Description

At face value, sending just you and your wingman up against 12 enemy aircraft looks a bit unfair. However, two things are working to your advantage. Your plane is pretty stealthy, and your enemies are flying into a gunfight armed to the teeth with – knifes and stones. To wit, the F-16s sport just one AIM-120C and one Sidewinder each, the F-14s have only one Sidewinder and the A-10s have only their guns. Is that a smile on your face? There is one other flight out there, 2 F-16Us, but unless you invite them to the party, they pretty much mind their own stuff.

Those U-models will be the first enemy fighters you will see when you enter the mission, they are a bit left of the waypoint heading. However, the enemies you should concern yourself with are coming in a bit from the right anyway, change your initial heading by about 20 degrees to the right to head directly for the mission objectives.

Since you enjoy a considerable advantage in both detection and weapons range, you should keep the fight at BVR ranges at all times, even that means you have to turn away and extend for a while. Take out the F-16s first with the AIM-120Rs, they represent the greatest threat since they have a token long range capability. The F-14s might detect you at a longer range, but cannot do much about it, so they should come second. Before you dispatch the A-10s, you might ask their drivers nicely whether they would not prefer a voluntary ejection to being shot out of the sky, at this point, the fight becomes really a bit one-sided.

Mission 8

Air Egypt

Mission Type

Fighter Sweep

Mission Objectives

You must land at Yanbu al Bar.

You must pass over Waypoint 5.

Allied Tornado flight WAHID 1 must not be destroyed.

Mission Description

In the last mission, you have demonstrated that you can handle a large number of enemy fighters. For this hop, the task is basically the same – shoot at everything in sight. However, this time, you will be going up against the enemy's first team. This mission will also require a stop at the airborne petrol station. Do not even think of skipping the refuelling, you will definitely need the fuel.

Your success in this mission will pretty much depend on how good you are at avoiding being sucked in too close to the fight and your ability to keep a pretty chaotic situation sorted.

En route you will note that a flight of F-16s and another flight of F-22s are heading towards the same target area, and you should take advantage of these reinforcements by adjusting your speed so that you enter the fight behind those two groups. For the F-22s, that should not be too difficult, they are pretty eager to get into the fight. The F-16s, however, take their time and you will have to throttle back to keep them out in front. The F-22s will usually head straight into the middle of the fight, whereas the F-16s will tend to approach the right edge.

You should definitely follow the F-16's example. The general rule for 1vMany or 2vMany is to keep outside the so-called 'gaggle' and to make sure that you keep all enemy fighters on one side. It will be a bit difficult to convince your wingman to take that advice, once ordered to engage, he tends to be drawn in and will most likely not last very long.

But even if your wingman and the other two groups of fighters do not survive for long, they tend to improve the odds a bit by eliminating a couple of enemy fighters and by inducing them to waste their long-range missiles, of which they do not have that many to begin with, on them. Your general tactic should be to fly along the edges of the dogfight arena, pick one or two fighters which are close to you, engage them with long range missiles and extend again. By following this tactic, the enemy fighter force should be reduced to a manageable number for the dog fight part of this mission.

If you think you are through with the mission once you have dispatched all the enemy F-22s, you are unfortunately wrong. Although it is not too likely that they will get past the Tornado's EF2000 escort, the incoming enemy JSF and Hawks might just get through, in which case you will lose the mission. Therefore, you should take them out as well. However, there is no need for you to charge in alone, you can wait for the EF2000s to join you. While you wait, you should check the mission objectives to see whether you have already passed over waypoint 5, if not, use the wait to do just that.

Once the EF2000s have arrived, it is time to engage the remaining bandits.

Mission 9

Threat Kill

Mission Type

Mobile Strike

Mission Objectives

7 SS-23 SCUD launchers and 1 train must be destroyed.

You must land at Dunqulah dispersal.

Mission Description

Due to the Iraqi's ingenuity at camouflaging the SCUD launchers, hunting them was probably one of the most frustrating tasks allied pilots had to face during Operation Desert Storm. Luckily, this mission will not be that difficult. Although this will probably become your longest lasting mission so far, it is more a matter of flying the route than actively searching for targets, they are all nicely distributed in the various kill-boxes. With three wingmen along, you will also have enough firepower.

The first kill box is exactly at waypoint 2, and the two SCUD launchers deployed there are also pretty well defended. There are a couple of SAM launchers and AAA vehicles next to the launchers, and a CAP flight of two F-16Us is circling beyond the target as well.

Handling two F-16Us with four F-22s should definitely not be a problem, but due to the relative positions of the SAMs and the CAP, just charging at the fighters will result in having the dogfight happen very close to or even on top of the SAM launchers, definitely not the place to conduct a fight.

In order to avoid that, turn left once you have detected the fighters and loop around until the fighters are between you and the target area, thus ensuring the ensuing fight will occur outside the enemy SAM range. Order your wingmen to engage, and since you will probably not be needed to kill the CAP, proceed to destroy the two SCUD launchers hidden amongst the city buildings.

The rest of the mission is pretty much a milk run, except for the last two SCUD launchers hidden somewhere in the last kill box. The area where you have to look for them is a high plateau, and the two launchers are hidden at the bottom of a small, circular valley on that plateau (which looks very much like a crater left by the impact of a meteor). Unfortunately, they are protected by a SA-6 SAM launcher and a Vulcan AAA vehicle. If you do not approach the valley very carefully, the SAM launcher will detect and fire at you before you know what is happening.

As you approach the last kill box, look very carefully for said valley and approach it at low level. Let your sensors look into the valley just long enough to build a shoot list. At this point, you will probably already be fired upon by the SAM launcher, so order your wingmen to engage the hostiles before you duck back to low level to avoid the inbound SAM.

Mission 10

Raid Egypt

Mission Type

Strategic bombing

Mission Objectives

2 Multistory Office Buildings must be destroyed.

Powerstation must be destroyed.

Chimney must be destroyed.

Control Tower must not be destroyed.

2 Barracks must not be destroyed.

You must land at Yanbu al Bar.

Mission Description

The list mentions some buildings that have to be destroyed and some which must not be destroyed, and this might lead you to the wrong assumption that the allied Headquarters is concerned about collateral damage. However, the Control Tower and Barracks are those at your very own take-off airbase, there is an enemy strike inbound and before you can commence your bombing mission, you have to intercept the inbound bogeys before they can release their weapons.

Although it takes quite a while to win this mission, it can be lost within the first two minutes. The intruder's escort is already overhead and the bombers are just a couple of miles away. With one escort flight of 4 MiG-29Ms and three waves of bombers consisting of 4 MiG-27 bombers each, assigning priorities becomes very important. Of the incoming bombers, the 4 coming in on a bearing of 130 degrees are the least dangerous, they do not carry any bombs and are thus just a diversion. The MiG-29Ms circling overhead and the four MiG-27s coming in from 330 degrees are second greatest danger, as soon as you have taken off, order your wingmen to engage, between them and the base's air defences, they ought to be able to handle that threat.

However, the most dangerous bomber wave is sneaking in over the mountains west of the airbase, and you should concentrate on this group. As soon as you are airborne, turn right until you are flying due West, jettison your bombs, go to EMCON 3 and select the AIM-120Rs as your active weapon. As you climb over the edge of the mountains, the MiG-27s should come into view. Build a shoot list and start shooting immediately, they will be well within range. When you have taken care of them, turn back towards the base and help your wingmen to fight the other bomber waves.

After the successful defence of your air base, it is time to go on the offensive again. The first step is to rearm and refuel. To do that, land at

your base without asking for permission to land (if you do, your wingmen will land as well and will not come back up again) and come to a full stop on the runway, your weapons and fuel will be restocked immediately. Take-off again, turn towards the first waypoint and engage the autopilot.

For the attack part of the mission, you will have a Wild Weasel Escort of four F/A-18Es, and progressing on autopilot will give them a chance to catch up and will keep the formation intact once they have closed the distance.

As you proceed into enemy territory, a couple of SAMs will light up and some enemy fighters will come to the party as well, but both threats should not present a problem.

For the attack itself, you should mentally prepare yourself for the fact that you will have to take out at least three targets, your wingmen will only go for the power station. Therefore, you must at least take out your primary target, the second office building (Figure 1) and the chimney. If your wingmen play Dilbert again, the power station is yours as well. Although quite a task, you should be able to pull this off, considering that you have 4 LGBs on board. In case you miss with one of the bombs, you have the option to either strafe the remaining buildings until they are destroyed or take the more realistic approach to return to your air base, to rearm and refuel again and to visit the target once more.

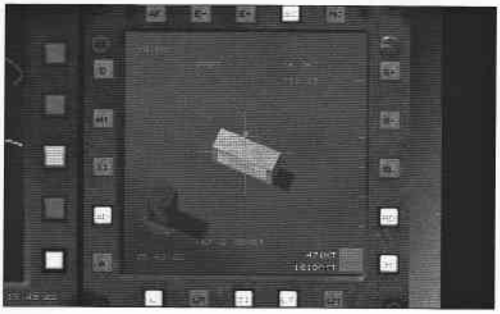


Figure 1

Part II Eritrean Tour

The scenario in the second Tour of Duty is another of the so-called 'Brushfire' or small-scale wars. After several years of squabbling, Ethiopia has finally resorted to violence to get access to the Red Sea and has invaded into southern Eritrea. You will fly as part of an international UN force dispatched to push the invaders back across their borders. The neighbouring countries have pledged neutrality in this conflict, so you have to be careful not to stray into forbidden territory during your missions.

Mission 1

Deny Flight

Mission Type

CAP

Mission Objectives

You must kill Su-25 flight ASHRA 4.

You must kill Su-25 flight ASHRA 6.

You must kill Mirage flight COCA 5.

You must kill MiG-21 flight KHALAZ 9.

You must land at Jizan.

Mission Description

This is a nice and easy mission to ease you into the new environment.

Summed up, the target flights consist of 9 planes, a number you and your wingman should be able to handle easily, especially since you are not exactly facing top of the line air superiority fighters. The target flights will be the first ones flying into your vicinity, so there is no need for any lengthy target identification or discrimination.

With careful use of your wingman, the air combat part of this mission should be wrapped up in 5 minutes, if you take longer, additional fighters might become a problem. The flight home is uneventful, so you do not need to hold back on the missiles.

Mission 2

Essential Supplies

Mission Type

Escort

Mission Objectives

Allied C-130J Flight Herky 1 must pass over waypoint 3 and survive.

Allied C-130J Flight Herky 5 must pass over waypoint 3 and survive.

You must land at Asmera.

Mission Description

Your task is to make sure that the C-130Js reach waypoint 3 unmolested and can deliver their supplies. Since it takes just one missile to kill a C-130J, you must make sure that no enemy fighter gets within striking distance of the relief flights.

To achieve this goal, you must constantly think ahead and evaluate which enemy planes might become a threat and, just as important, when. By the same token, despite the considerable number of enemy flights out there, you do not have to kill all of them. Enemy flights which pose no threat to the transports can well be left alone.

When you enter the mission, you will be a bit behind the transports, short of waypoint three. The most serious threats to your sheep will come from two directions. There is a flight of two Su-27s sitting smack on the route to waypoint 3, and two MiG-21s are boring in from beyond waypoint 2. In order to deal with this, you need to split your forces. First, head towards the Su-27s, build a shoot list and order your wingman to engage them. Then, turn back towards the MiGs and deal with them.

You can pretty much handle all of the remaining threats in the same way, order your wingmen to deal with one threat and engage the next one yourself.

Mission 3

CAP UK

Mission Type

CAP

Mission Objectives

UK EF2000 flights ECHO6 and ECHO7 must survive and pass over waypoint 2.

Control Tower must not be destroyed.

You must land at Akordat.

Mission Description

In this mission, you must basically sanitise the area around waypoint 2 completely. The EF-2000s have to get and land there without a scratch, and the control tower at the airfield at waypoint 2 must not be destroyed either.

The main threats to the tower constitute one flight of Su-25s, escorted by 4 Su-27s and one flight of Mirages, escorted by two MiG-21s.

The Su-25s will appear first, and you should hurry to intercept them as far out as possible. On the way, you will come across a flight of 4 Ka-50 attack helicopters. Just to be on the safe side, shoot them down as well. Keep one eye on your defence MFD, you will come pretty close to some enemy SAM sites, make sure to stay out of their range.

After you have eliminated the first threat, hurry back, the next threats are already inbound. Do not fly directly towards them, you will come to close to enemy SAM sites. A better way is to fly back to waypoint 2 and turn towards the threats from there. On this intercept, do not bore in at full afterburner, again, you will get too close to the SAM sites. Instead go in at 100 percent military power, shoot the single MiG-21s first and turn towards the strike afterwards.

When you have handled those threats, you will probably be either out of or pretty low on missiles, so get back to the airfield at waypoint 2 for a short rearming/refuelling stop. Get back into the air as fast as possible again and fly top cover until all EF2000s have landed. If they are all safe on the ground, head home.

Mission 4

Armed Recce

Mission Type

Reconnaissance

Mission Objectives

You must pass over waypoint 5 and land at Jizan.

Mission description

'3 hours of boredom and 5 minutes of terror' were the words with which a fighter pilot described combat once. This mission is not quite so bad, you will only be bored for about an hour, and, if executed properly, the terror will only last 2 minutes.

At face value, this mission sounds like a replay of the very first mission in TOD 1. This is partly right, but it is a bit more difficult than that. The added challenges include a night refuelling and the lack of A2G weapons.

After refuelling close to waypoint 3, get back on the route towards the target and get down to low level. Until you come up to your recce waypoint, things should be pretty quiet. Once you have crossed the last mountain between you and the target, it is time to concentrate. Your target waypoint is an airfield which is heavily defended by SAMs and AAA, and in contrast to the first TOD 1 mission, you do not have any long range weapons to disable them with.

However, the mission can still be done. As you crest the last mountain, you should see a road leading towards the target. We will follow that road, as it will give us an even surface for ultra-low-level flight and, since it leads through a small valley, it will help to shield us from the other SAM sites. To approach the target waypoint undetected, we will take advantage of our reduced signature at idle throttle. When you are over the road, get down to an altitude between 100-150 feet. Head a bit to the left of the waypoint and keep an eye on the defence MFD. Approach the target with the throttle wide open until the you are almost in detection range and then throttle back to reduce the detection distance.

Unfortunately, even at idle throttle we would get into detection range before the waypoint readout jumps to the next waypoint, so we have to use another characteristic of the F-22's stealth design. At certain bank angles, you are completely invisible. Although this is a state that usually lasts only for a very short time and is as such not something on which you should rely on a regular basis, a few seconds is all we need for this mission. The bank angle we need is a very slight one, about 10 degrees. When you are very close to the target, already at idle throttle and the detection range closes in, start a very slight, 10 degree bank and 10 degree climbing turn out of the valley. You will still reduce the distance to the waypoint and the active waypoint will jump to 6 shortly after you have initiated the climbout. Keep up the slight turn and only tighten it when you crested the valley's sides. Continue to turn around very carefully, and open the throttle only when you are sure this will not put you into anybody's detection range.

Once you are away from the SAM sites, head for home, the flight should be pretty quiet from there on.

Mission 5

Power Down

Mission Type

Strategic Bombing

Mission Objectives

The Power Station must be destroyed.

You must have refuelled.

You must land at Jizan.

Mission Description

The increasing pressure the allied forces are bringing to bear on Ethiopia is beginning to show the first results. It seems that the Ethiopian Forces have largely stood down to regroup. As you may have already noticed during your previous mission, the enemy resistance is at a pretty low level at the moment. This fact, combined with the data you have collected on your previous recon mission, make this bombing mission is a pretty straightforward hop.

Just like the previous mission, this one is impossible to complete without refuelling, though this time, it is part of the requirements for mission success. Therefore, once you are close to waypoint 4, look for the refueler and hook up before you continue.

In this mission, the only defences you have to pay attention to are close to the target – a couple of SAMs and one CAP flight. Since you are carrying JDAMs, you can execute this attack in two different ways. If you lean a bit towards the aggressive, take out the CAP flight before you continue towards the target and drop the JDAM from level flight. On the other hand, if you consider hitting the primary target as the major part of your job description, execute a low-level ingress, pop-up and toss attack.

Mission 6

Force Green

Mission Type

Wild Weasel / Fighter Sweep

Mission Objectives

The allied F-15E flights EAGLE4, EAGLE5, EAGLE6, EAGLE7, EAGLE8 and EAGLE9 must survive.

The allied F-22 flights WOLF3, WOLF4 and WOLF5 must survive.

You must pass over waypoint 4.

You must land at Dalol.

Mission Description

Headquarters wants to take advantage of the lull in enemy activity and strike a decisive blow while they are reconsidering their position. Therefore, a massive attack against numerous airfields will be flown at first light. Your job is to make sure that both the air and ground based defences will be neutralised when the strike forces sweep down on their targets.

Since you will be accompanied by three wingmen, firepower will not be much of a problem, but in order to make sure the strike flights enjoy a peaceful run at their targets, you will not only have to destroy a

considerable number of targets, you will also have to do it in a very short time. As you have to be finished at each of the airfields before the strike flights arrive, you will have to meet several, closely spaced TOTs (Time on Target) to get the job done.

The first targets, two ADF units, are near waypoint two. You should have taken out these targets by 6:05, and although the sight of all those fighters sitting on the tarmac without any defences left almost cries for repeated strafing runs, you should resist that temptation. As you will see on the Situational MFD, the strike flights are already on their way in, and the F-22s going for the airfield at waypoint 4 are going flat out, so you should get on towards the next targets.

The next two groups of ground based defences are near waypoint 3 and in the middle between waypoints 3 and 4. Your strategy concerning them should be a straightforward and fast attack. Highlight them for your wingmen and order them to engage the targets without wasting much time on them, one run of your wingmen should be enough. Continue your progress towards waypoint 4, you need to have cleared the defences there by 6:15.

At waypoint 4, you will meet enemy fighters for the first time, a CAP of 4 Su-27s. Since there will be SAMs as well, you have to divide the workload. Order your wingmen to engage the bandits and drop down to low level to take out the SAMs and AAA yourself. Once the ground based threats are gone, go up again and, in case they are not finished yet, help your wingmen to dispatch the Su-27s.

Although you will have racked up an impressive list of kills by now, your work is still not finished. Collect your flight and hurry to get to waypoint 5, you need to be there before the strike flights arrive by 6:25.

As you come up to waypoint 5, you will notice that the air defences around that airbase are spread out a little. The really nasty example is the one closest to you as you approach, therefore, order your wingmen to engage the other threats and handle the tough nut yourself.

The problem with that particular SAM launcher is where it is deployed – it sits in the middle of a circular depression which makes it very difficult to attack it without drawing fire yourself. Although it looks like you can easily attack it from all directions due to a bug which allows weapons to track objects through mountains, the only really easy direction to attack from is from the East, since the granite 'ring' around the SAM is bit flatter if you come in from there. Therefore, extend towards the east for a few miles before you come around to attack the SAM launcher.

By the time you are finished with the special job, your wingmen should have eliminated the other defences. However, your job is still not done. The enemy will launch two groups of 4 Su-27s each rather

precisely at the time the strike flights come in, and you have to stick around to take alert fighters out before you can finally head for the barn.

Mission 7

Tower 3

Mission Type

Strategic Bombing

Mission Objectives

Control Tower and 3 Hangars must be destroyed.

You must land at Dalol.

Mission Description

The effort to reduce the enemy's offensive capability continues, and today's mission calls for you to take part in another strike at an enemy airfield. However, this time, you will be part of the strike force. The enemy long range air defences and airborne CAPs have already been eliminated, but you still have to contend with AAA and alert fighters.

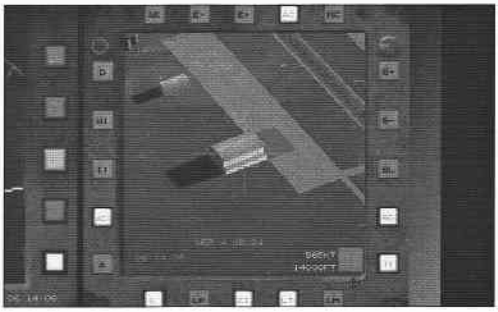


Figure 2

The biggest problem in this mission is that your wingman will be no help at all in destroying the mission objectives. He will never hit one of the targets with his LGBs, and therefore, you have to take out all the targets yourself. Figure 2 shows you what your secondary targets look like.

Taking out four targets with four LGBs is doable, and the main goal in this mission run through is to show you how to get the time to conduct the repeated runs over the target unmolested.

Avoiding the AAA at the target is pretty simple, just stay high, they will not hit you if you stay above 6,500 feet. However, just as you arrive at the target, a flight of four MiG-29Ms is taxiing to the runway, and these guys will certainly object to you blowing up the place. Since your A2A weapons loadout of 2 AIM-9X Sidewinders is not exactly lavish, you should use your two Mavericks to destroy two of the fighters while they are still on the ground.

After that, stay high and circle above the airfield and wait for the MiGs to take off. Once they are off the ground, order your wingman to engage and get into the fight yourself. Since the MiGs are not too manoeuvrable immediately after take-off, killing them should not be too difficult.

With the MiGs gone, you are home free as far as the LGB attacks are concerned. Although another flight, consisting of four Mirages, will

take off while shortly after the MiGs, they are on a bombing mission and will not attack you unless you attack them first.

Since attacking them will only get in the way of accomplishing your primary mission, I would suggest that you simply let them go – you have more important things to do.

In case you miss with one of the bombs, remember that you can always fly back to your base to rearm and refuel, a miss does not mean that you cannot accomplish the mission anymore.

Mission 8

15 Down

Mission Type

RESCAP

Mission Objectives

You must destroy enemy MiG-21 flights KHALAZ1 and KHALAZ2.

You must destroy enemy Su-27 flight KWAYYIS 1.

You must destroy 5 enemy AMX-10RC, one SA-11 launcher and one ZSU23/4 AAA vehicle.

You must pass over waypoint 5.

Allied Stallion flight RESCUE1 must not be destroyed.

You must land at Jizan.

Mission Description

Although the preceding two strike missions were very successful, they were not without costs, two F-15Es have been shot down. Both crews ejected and have been located. Your task is to make sure that the rescue flight does not get attacked, either by airborne or ground based forces.

The main problem with this mission is that you will be flying into a very target rich environment and that you must make sure to launch your weapons at the right targets, otherwise you might run out of ordnance before you have eliminated all mission objectives.

On the way to the target area, your wingman will be rather eager to engage the neutral flights along the way, but since those do not represent a threat at all, do not let him engage them.

The first real threat you will have to handle will be a lonely Su-27, but that should not be a problem. As you close in on the target, more and more SAM sites will announce their presence. Do not waste your ordnance on them, you can put it to better use in the target area.

All your mission targets will be in or very close to the killbox at waypoint 5. The first two AMX-10 RCs will be just outside the killbox, the two ADF units will be sitting at the edge and the

remaining three AMX-10 RCs will be travelling with a group of tanks right through the middle of the killbox.

We recommend that you assign the first two AMX-10 RCs, the SA-11 and the ZSU23/4 to your wingman and that you dispatch the three AMXs travelling with the tanks. As you close in on that group, you will again suffer a bit with the way the Maverick shoot list is being built. Since there are six tanks at the front of the group the six available shoot list slots will all be assigned to the tanks. To get the AMX-10s into the shoot list, you have to either hand-build the shoot list or you have to fly over the group, turn around and attack from the other direction. Since the AMX-10s will now be closer to you, they will be put into the shoot list along with three of the tanks. But no matter how you put them into the shoot list, the Mavericks will certainly take care of them.

With the ground based targets all gone, it is time to concentrate on the 3 enemy flights you have to kill. Well, here comes the good news, depending on the time you needed to eliminate the ground threats, they might not even be airborne yet. They will all take off from the air base a couple of miles east of waypoint 5, and if you hurry, you can catch them while they are still on the ground. The icing on the cake is that the enemy air defences are deployed well outside of the base. With a bit of caution, you can get in and kill the planes on the ground without drawing fire in return.

Since there are more than the four target planes on the ground, you can either use the data readout on the Situational MFD to determine which planes are your target, or, probably easier, just destroy them all.

With all the threats at the target area destroyed, you can go home and end the mission with a clear conscience. Although the chopper has not picked up the crew yet, it is highly unlikely that something untoward will happen to it. Unfortunately, if you insist on accompanying the chopper home, or take too long to accomplish your tasks and land, you will lose the mission, the chopper will run out of fuel on the way back and crash.

Mission 9

Para Watch

Mission Type

AWACS

Mission Objectives

Galaxy Flights SLIP1, SLIP2, SLIP3 and SLIP4 must fly over waypoint 5.

The WASP group of ships must survive.

Mission Description

It had to happen sooner or later – your extraordinary tactical skills have been noticed and you have been kicked upstairs to command the conduct of a whole air battle from an AWACS plane. For a real fighter pilot, this would be about as welcome as having to eat shredded glass for breakfast each day, in fact, he would probably prefer the latter to the desk job in the AWACS. In this game however, you have the best of both worlds. You can shape the course of the battle from the AWACS and you can still jump into an F-22 cockpit whenever the need arises or you just feel the urge to do so.

In the actual mission, the goal is to recapture two ports and an airfield still in Ethiopian hands. Your job is to ensure that the Galaxys carrying the paratroopers will make it to the target and that the Marine's base ship, the attack carrier Wasp, does not get destroyed during the attack (does not happen anyway, nothing threatening comes close).

Figure 3

In order for the Galaxys to make it to their respective waypoints 5, you must not only eliminate all the enemy fighters close to their targets, even more important is that you kill the enemy air defences deployed at the target area. Although the Galaxys have a Wild Weasel Escort, there are too many units for them to handle. In Figure 3, you can see which units you have to destroy, they are the four groups north of the Aseb Army Headquarters.

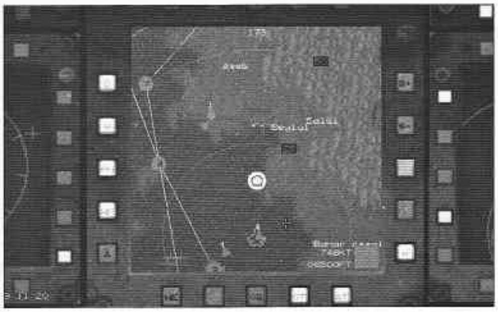


Figure 4

To support them, watch Djibouti closely, about 10 minutes into the mission, two CAS flights will take off from there. Once they are up, order them to attack the air defences immediately. In addition, there is also one F-22 CAS flight inbound (IRON7), once it gets close to the target area, jump into it and attack what is left of the air defences. Combined with your wingman, you are carrying 16 Mavericks, this should be enough to kill the remaining defences (see Figure 4).

With the air defences gone, the Galaxys will have no trouble reaching their drop waypoints and once the last group has passed it, the 'End Mission' box will come up.

Mission 10

Air Cover

Mission Type

AWACS

Mission Objectives

3 M1 groups and 1 Humvee group must survive.

2 BMP3, 1 T80 and 1 BRDM2 groups must be destroyed.

Chinnok flight MAKTAB1 must fly over waypoint 4.

Mission Description

After the successful capture of both the airfields and the port, the purpose of this mission is to capitalise on those gains by expanding your bridgehead, eventually clearing all remaining pockets of enemy resistance. Your task is to co-ordinate the allied flights to maximise their effectiveness.

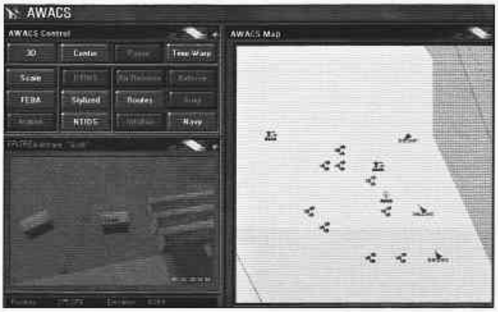


Figure 5

Although it takes quite a while to win this mission, it can be lost within the first two minutes. The reason for this is that one of the M1 groups that has to survive is already very close to the enemy (see Figure 5).

As you can see, the only allied forces around are three Apache CAS flights, vector them immediately towards the enemy. This is all you can do for the moment, but unfortunately, it may not be enough. Sometimes the last M1 dies before the Apaches have a chance to even the odds a little. There is no other way to put it, unless luck is on your side, you cannot win this mission. However, sooner or later the tanks will survive, so let us take a look how to proceed from there.

In order to kill all the enemy groups listed in the mission objectives, you have to wipe the area shown in Figure 5 clear of the enemy, all your enemy targets are concentrated there. Your secondary concern must be to keep the air space around the MAKTAB 1 flight clear of enemy interceptors. If they get one whiff of the helicopter, it is dead.

Accomplishing the first task is pretty easy, you will have loads of CAS flights you can vector onto the enemy ground troops. The second one is a bit more difficult, because you might run out of suitable CAP and Escort flights later in the mission. Should that happen, you will have no other alternative than to jump into the cockpit yourself. Although you cannot vector F-22 CAS flights onto enemy aircraft, you can still use them to intercept the enemy fighters yourself. With an A2A loadout of 6 AIM-120Cs and Sidewinders, you actually stand a better chance of taking out the enemy fighters than the refusal of the AWACS command interface might lead you to expect.

However, you should remember not to spend too much time in the cockpit, lest you lose the big picture. Once you have eliminated the immediate threat, get back into the AWACS again.

As already stated, it may take several attempts to win this mission, so do not get overly frustrated if things do not go your way at the first couple of tries.

Part III YemenTour

In an attempt to secure their access to the large oil deposits near the long disputed border between Saudi-Arabia and Yemen, the Yemenite government is backing a group of rebels which have declared their independence from Saudi-Arabia and have gained control over the south-western part of Saudi-Arabia.

Since Yemen has bought a considerable amount of the latest and best weapons from both Russia and China, this final Tour of Duty will be considerably more difficult than the preceding tours. Especially the Su-35 with its powerful radar and long range R-77R 'AMRAAMski' air-to-air missile represents a much greater threat than the fighters you have duelled with so far.

Mission 1

Border Patrol

Mission Type

CAP

Mission Objectives

Enemy MiG-29M flight KHALAZ3 must be destroyed.

Enemy Su-35 flight GHAALI3 must be destroyed.

Allied E3 flight MAGIC1 must not be destroyed.

You must land at Ash Sharawrah.

Mission Description

During the recent days, the Yemenite fighter activity along the disputed border has increased considerably. Headquarters are concerned that the enemy is trying to detect weak spots in our defensive screen to dash across the border and to kill our E3 AWACS planes before they commence full offensive operations. Since they are sending their top-notch fighters up, we will do no less - it is up to you to spoil their plans. You are tasked to take out the two enemy flights we suspect to have the AWACS as their target.

When you hit the cockpit, your targets are already pretty near, they are directly ahead close to waypoint 2. Another enemy flight is closing in from around 2 o'clock, which you should ignore.

Although the rules of engagement sound pretty restrictive, you do not need to be overly concerned. Even if you ignore them completely, you will not be penalised. For the Su-35s, you are in the clear anyway, since they will attack another allied fight shortly after you enter the mission. Go to full burner and take advantage of the fact that their minds will be occupied for a while.

The MiGs are bit less aggressive, they seem to be perfectly content to fly along their CAP route behind the border. This means that, since you have to kill them to accomplish the mission, you will have to go in. Even four MiGs should not represent too much of a problem for you by now, but due to the numerous SAM sites along the border, you have to choose the place where you engage them very carefully. Entering into BVR or, even worse, close quarters combat near all those SA-6 and SA-11 SAM launchers is a recipe for disaster.

In order to avoid that, sneak in through the gap in the SAM coverage and engage them from there, you are much more likely to succeed if you can concentrate on one threat at a time.

Mission 2

Air Rebels

Mission Type

Search and Destroy

Mission Objectives

Captured allied F-15Es ARBAA2 must be destroyed.

Enemy Su-30 flight KHALAZ2 must be destroyed.

Enemy Su-35 flight GHAALI1 must be destroyed.

You must land at Khamis Mushayt.

Mission Description

When the rebel forces set up shop in southern Saudi-Arabia, they did, amongst other things, capture a couple of allied planes. If those fighters were to be used, confusion and chaos would reign – the rebel planes would have no trouble getting through, and blue-on-blue incidents would certainly reach an all time high. Your job is to find and to destroy the planes before they can be used against the allied forces.

Depending on whether the other allied fighters on patrol have a good day or not, this mission can be either a milk run or a pretty rough ride. When you get airborne, the first of your enemy target flights will

probably already be in the middle of duking it out with a couple of F-15-Ds. If our guys do have a good day, they may already have done a good chunk of your work by the time you arrive at waypoint 4. Your chances of getting a piece of that action improve significantly if you do not follow the flight plan, but fly to said waypoint immediately.

When you get close to the combat arena, take a note of all the enemy SAM sites and make sure that you do not get involved into a fight too close to one of them. Once you have chosen where to fight, dispatch what is left of the KHALAZ2 flight. Since you happen to be in the neighbourhood, take care of the inbound flight of MiG-29Ms and the ANT-70 transport planes plus escort which will take off from the airbase at waypoint 4 as well.

Once the air picture is clear, it is time to look for the captured allied planes. By a happy coincidence, they are also at the airbase at waypoint 4. However, since the airbase and the area around it is pretty much infested with SAM sites, you and your wingmen will have to roll back the defences before you can destroy the F-15Es. By the way, since the weapon computer will correctly identify them as allied planes and will not put them into the shoot list, you will have to put them in manually if you want to destroy them with Mavericks.

When you have destroyed the F-15Es, you still have to find and destroy the Su-35s. The problem with those guys is that they have not figured you would take a shortcut to waypoint 4 and hence, they might still be a considerable distance away. In case your A2A weapon loadout is a bit on the low side, use the time to dash back to Khamis Mushayt to rearm and refuel.

With a fresh load of weapons on board, get back to waypoint 4, the Su-35s should be there by now. In case they are still not there, fly due East until you see them and dispatch them as well.

Mission 3

Sea CAP

Mission Type

Anti-Ship

Mission Objectives

7 Container Ships.

2 Oil Tankers.

You must land Dikhil dispersal.

Mission Description

Unless you are closely related to Attila the Hun, Dschengis Khan or Saddam Hussein and do not care about endangering or taking the lives

of innocent bystanders, you should not fly this mission at the hard level.

The problem with this mission is that you are tasked to kill specific ships travelling in a body of water amongst ships that look exactly like your targets - and that there is no way to tell them apart. If you fly this mission at the hard level, it is just as likely that the oil tanker in your sights is a neutral or even a friendly instead of an enemy. Neither your plane's avionics nor a low level fly-by will clear the mystery, and the only chance to succeed would be to kill them all (which would necessitate at least one refuelling/rearming stop) and to let St.Peter sort them out.

In the real world, target discrimination is definitely a bit more advanced than the 'Yeah it is an oil tanker, let's shoot it' - approach. The ship's name can be used to trace its origin, the shape and layout can be compared against relevant reference data bases and the ship might even be flying the national flag. If it would not be possible to determine exactly whether a ship was hostile or not, the ship would, in all likelihood, be left alone.

Therefore, even if you are a 'Hard is the only realistic level' kind of guy, flying this particular mission at the medium level simulates reality more closely than doing it at the hard level.

Even at the medium level, it is not a complete washout. Granted, target discrimination becomes a bit easier, but you still have to get within 50 miles of the target before your aircraft's avionics can tell friend and foe apart. Since the targets are pretty well distributed over the whole Gulf of Aden, finding them all will therefore require you to fly out and meticulously check each and every olive cross on the water, all whilst trying to avoid the attention of the numerous enemy CAPs and the armed enemy ships out there.

Mission 4

Air Force

Mission Type

Fighter and SEAD Sweep

Mission Objectives

Enemy Su-30 flight SHAR1 must be destroyed.

Enemy Su-35 flight GHAALI2 must be destroyed.

Enemy MiG-21 flight KHALAZ2 must be destroyed.

Enemy MiG-21 flight KHALAZ9 must be destroyed.

Enemy Su-27 flight KWAYYIS1 must be destroyed.

SA-11 group must be destroyed.

ZSU23/4 group must be destroyed.

You must land at Ash Sharawrah.

Mission Description

Pretty large order, isn't it? Well, depending on how much you like taking off with enemy fighters circling overhead, there is nevertheless good news ahead – you will not have to search very long for your targets. In fact, the first two enemy fighter groups will already be so close at the start of the mission that you will not be able to time-skip to the runway, you will either have to self-taxi or let the autopilot take you to the runway.

No matter how you got to the runway, you should definitely wait for your wingmen to catch up before you blast off – the enemy fighters will be within missile range, and the allied CAP might not get them all. However, despite the temptation to engage the fighters as soon as the wheels are in the wells, build up your speed and extend a bit before you turn to engage. If possible, do not get into the close and dirty range, you should rather pick your targets from outside the fight and engage them with long range missiles. Caught between you, your wingmen and the allied CAP, the enemy fighters should not last too long.

Depending on how many missiles you have already used up, you might dash down to your base for a quick rearming/refuelling stop before you continue the mission. With the sky clear of enemy fighters for the moment, the SAMs and AAA are next. Your targets are all pretty close to waypoint 5, two groups are at the enemy airbase and one is near the adjoining city. Since the F-15Es you are supposed to clear the area for will usually not enter the fight over the base, they will already have a good head start, so flying directly to waypoint 5 might be the only way to get to the target area ahead of them.

Due to the large number of SAMs and triple AA at the target area, it will be rather difficult to induce your wingmen to engage the right targets, and with a load of just four HARMs, you cannot kill everything they miss. However, with your base more or less just around the corner, just get back there quickly to restock your armament again.

By the time you get off the ground after the second rearming stop, the remaining enemy target flights will be airborne as well, and you might have to take a break from SEADing to play Red Baron again for a few minutes. The Su-27s will sweep towards your own base again, whilst the two MiG-21 flights will fly a CAP close to their own base. The nice thing is that the enemy flights will sort of distribute themselves in such a way that they cannot mutually support each other, you can pick them off one by one pretty easily.

With the A2A threats all gone, it is time go back to the enemy air base to mop up the remaining SAM launchers and ZSUs.

Mission 5

Scramble

Mission Type

CAP

Mission Objectives

Enemy Su-30 flights SHAR3, SHAR4 and SHAR7 must be destroyed.

You must land at Ash Sharawrah.

Mission Description

In this mission, the number of target planes is pretty manageable, the problem is that they are accompanied by a considerable number of well armed escorts, and those packages are themselves protected by 'free fighters' preceding them and sweeping through the air above your base.

For you, this means you have to avoid getting involved with the flights that are not your targets, once you get drawn into a fight with the protecting fighters, you are bound to become more concerned with saving your life than with shooting down the incoming bombers.

As usual in such a situation, staying on the periphery of the fight is the key to success. The target flights are coming in along two different bearings, SHAR3 comes in from 200 degrees, escorted by 2 MiG-27s. SHAR4 (plus an escort of 2 Su-27s) and SHAR7 are both coming in from 240 degrees, and these flights also constitute one 'edge' of the enemy advance.

Immediately after take-off, you should therefore concentrate on those flights first. Until you are in missile range, I would suggest that you even fly due west to put some more distance between you and the other enemy flights. Do not worry about SHAR3, there are other allied flights out there, and since the mission objectives do not contain any 'XYZ must not be destroyed', there is no particular urgency involved.

You might have to issue several 'Disengage' calls to your wingmen, since they pretty much tend to shoot at the first enemy fighter they lay their eyes on. Keep them on a short leash, you will need their help to take out the two target flights plus their escort. Once the flights are in missile range, you should obviously concentrate on the escorts first – with them gone, the bombers are pretty easy to get.

After you have killed the first waves, turn back towards your base to see whether there any planes of the SHAR3 flight left. Do not be too

surprised if they are all gone, the other allied flights and the airfield's defences will usually take care of them. With a take-off time of 5:55, you have 5 minutes till daybreak. As an added challenge, try to be down on the ground again before sunrise!

Mission 6

Rebel Jizan

Mission Type

Search and Destroy

Mission Objectives

Su-35 flight NIKITA1 must be destroyed.

A-50 flight SHAZAM2 must be destroyed.

Su-27 flight KHALAZ4 must be destroyed.

Su-30 flight SHAR6 must be destroyed.

F-15E flight ARBAA1 must be destroyed.

F-15E flight ARBAA2 must be destroyed.

2 Container ships must be destroyed.

ZSU23/4 group must be destroyed.

SS-23 group must be destroyed.

You must land at Bisha.

Mission Description

After destroying the rebel's offensive capabilities during the last missions, we will now search them out in their hideouts and negate them the capability to rest and regroup their forces.

Although the mission objectives list has grown to a considerable length, you can confidently expect that you do not have to tackle it alone. Support in the form of other allied strike packages will keep the number of targets you will have to destroy yourself on a pretty manageable level. In addition, there will also be an unexpected boost to your capability, but more on that later.

In order to enjoy the support from the other allied flights in its fullest form, you have to ensure that you do not arrive too early at the target area. Therefore, I would suggest that you let the autopilot do its job of keeping you at the correct speed and hence, on time. When you are about 50 miles from waypoint 3, it is time to get to work.

Depending on how much the electronic dice have been in favour of the allied forces, the A2A picture might already look pretty clear. Although three of the Yemenite fighter groups (NIKITA1, SHAR6 and KHALAZ4) are bound to get close to waypoint 3 at about the

same time you should get there, it is not unlikely that the other allied fighters have eliminated some if not all of them already. In case there are some survivors, we would suggest that you take care of them first, an inbound A2A missile takes a lot of the fun out of blowing ground targets up.

Once the skies over the target area are clear, it is time to eliminate the ground targets. Finding them is not too difficult, the container ships are just off the coast, and the other targets, including the captured allied F-15Es are either at or very close to the airbase. Obviously, any remaining enemy air defence units are the first that have to go, so build a shoot list and do not forget to order your wingmen to help you out. With the air defences gone, you are pretty free on how to proceed further, though you have to keep in mind that only you can destroy the F-15Es, your wingman will not shoot at them.

Given the huge number of ground targets, even the considerable initial load of 12 Mavericks will be gone pretty quickly, and depending on the number of enemy fighters you had to take out yourself, your A2A loadout might also be pretty low by now. Ordinarily, such a situation would call for a quick dash back to the home base to rearm and refuel. In this mission however, the airbase below is a captured Saudi airbase, and once you have eliminated the air defence units around it, you can safely land and restock your supplies at your former target.

Rearmed, refuelled and with the work at the target area done, the Yemenite AWACS is the next item on the list. Somewhat logically, it is not circling close to or over Saudi territory, you have to cross the border into Yemen to find it. It is roughly to the South-East of waypoint 3, so once you are rearmed and refuelled, collect your wingmen to dispatch it. There are a couple of enemy interceptors you will have to eliminate before you can get close to the AWACS, but with a rearming point just a few miles away, there is no need to save on missiles, and the fighters should therefore not be a big problem.

Mission 7

City 1 Yemen

Mission Type

SEAD strike

Mission Objectives

Su-35 flight GHAALI1 must be destroyed.

Su-35 flight GHAALI2 must be destroyed.

Su-27 flight KWAYYIS1 must be destroyed.

Su-27 flight KWAYYIS2 must be destroyed.

Su-30 flight SHAR5 must be destroyed.

Su-35 flight SHAR6 must be destroyed.

5 SA-6 SAM launchers must be destroyed.

3 SA-17 SAM launchers must be destroyed.

You must pass over waypoints 6 and 7.

You must land at Khamis Mushayt.

Mission Description

Although the majority of the rebel forces have already been destroyed, Yemen is still not prepared to end the hostilities and large scale strikes on Yemenite targets have therefore been sanctioned.

As in the previous mission, the number of targets you have to destroy to succeed is pretty hefty. However, with a bit of foreplanning and by using the available support of the other allied flights and your wingmen, it is even possible to complete this mission without having to rearm back at the base.

Before you can start to blow things up, the first task to complete is the lengthy ingress, including the airborne refuelling stop near waypoint 2. As in the previous mission, the easiest way to make sure that the maximum support by the other allied flights is available is to let the autopilot handle the ingress.

As you come up on the target area around the waypoints 4 and 5, you will notice all the enemy air defences appearing on your displays and you might start to wonder how you are supposed to kill them all and how to make sure you are not wasting your weapons on worthless targets. Well, first off, you do not have to kill them all, and finding your mission objectives is actually pretty easy. Each of the ADF groups close to the waypoints 4 and 5 contains exactly one SAM launchers, and with 8 groups around, you have just found all your ground-based mission targets. With the help of the FLIR sensor, you should have no trouble to discriminate between the SAM launchers and the AAA. In order to save your ordnance, give your wingmen the first shots at the targets, and clear out what they do not get.

With the ground based mission targets gone, it is time to search for the remaining air targets. However, if you are a fast worker, the Su-27s might not be up yet. They are scheduled to take off from the airbase near waypoint 4 at 2 o'clock, and if you dispatched the SAMs rather fast, you might get them while they are still on the ground.

After you have solved that problem, you should start for home and be sure to pass over waypoints 6 and 7. While you are at it, the two remaining target flights SHAR5 and SHAR6 should come up on your displays. Since they are slated to bomb your landing air base, being a bit closer to home and having passed the waypoints 6 and 7 already is

not a bad thing, you do not have to play catch-up, and you do not have to fly back to said waypoints once the threat is gone.

Mission 8

Roulette

Mission Type

AWACS

Mission Objectives

Allied flights GHOST1 and GHOST2 must pass over their respective waypoints 8.

All the planes in those two groups must survive.

Mission Description

Even the heavy strikes executed during the previous missions were not enough to convince the Yemenite government to finally back down, and thus, the effort to bomb some sense into them continues. However, whilst the enemy has kept considerable forces in reserve and remains rather strong, the smaller allied contingent is already stretched pretty thin. Headquarters has identified the far from perfect mission co-ordination by the AWACS as one of the main reasons for our considerable losses to date. Remembering the good job you did in that position during the Ethiopia TOD, Headquarters has placed you in command of the whole theatre for the last two missions. Since our stealth attack squadrons have suffered the highest loss rate in any conflict so far, we have reached a point where we cannot afford to lose even one of those precious aircraft. In the upcoming mission, you have to do your utmost to ensure their survival.

The threat to the F117-As is twofold. Being subsonic bombers, they are dead meat if any enemy fighter gets close to them and due to the advances in Radar and IR detection technologies since the F-117As were developed, they can now also be detected and shot down by enemy air defence systems.

With the few allied fighters close to the border when the mission starts, this task will be impossible to accomplish. Therefore, after assigning the first intercepts, you should order the fighters tasked with patrolling over Saudi territory to fly closer to the border, and you should even consider stripping the refuellers of their escort. However, throughout the mission, enemy flights will try to sneak around the battle close to the eastern edge of the map to kill the AWACS, so you should keep an eye on that area.

As the mission develops, enough CAS and Interdiction flights will become available to destroy the SAMs and AAA along the flight routes

of the F-117As, but you may have to assign more than one flight to a target to make sure it really gets taken out.

Additional stones thrown in your way include a couple of alert fighters taking off close to GHOST2's target just as the flight GHOST2 commences the attack, you should therefore keep at least two flights of allied fighters close to that spot when GHOST2 runs in. When the F-117As are on their way back (and you might think you can start to relax), the enemy will launch a massive wave of strikes. By that time, you might be a bit low on fighters and might have to use a couple of CAS-tasked F-22s to take them out.

Finally, the AWACS does not want to stay to the end. Although the F-117As are nowhere near home by that time, the AWACS will leave its station by 02:00 hours or very shortly thereafter. If it lands before the F-117As have passed over their waypoints 8, you fail the mission. Although there is no way to stop the AWACS from leaving its station by that time, you can make sure that it does not land before the F-117As do by constantly redirecting it to another landing air base – as soon as it gets close to its currently assigned landing base, drag the AWACS's symbol over another air base.

Keeping those tips in mind, you should have no trouble getting the F-117As back to safety.

Mission 9

Final Missile

Mission Type

AWACS

Mission Objectives

A-50 flight SHAZAM1 must be destroyed.

MiG-29 flight KHALAZ5 must be destroyed.

SU-30 flight SHAR4 must be destroyed.

SU-35 flight SHAR5 must be destroyed.

SU-35 flight SHAR6 must be destroyed.

SU-35 flight GHAALI6 must be destroyed.

8 SS-23 Groups must be destroyed.

ANT-70 flight AL_Juma1 must not fly over waypoint 3.

Mission Description

Your brilliant co-ordination of the strikes in the preceding mission has left the enemy air force incapable to sustain offensive operations. The Yemenite government has therefore resorted to the use of ballistic missiles, with the US-used bases as their primary targets. In this

mission, you are therefore tasked to co-ordinate the search and destroy missions launched to eliminate this last remaining threat.

In order to have the time to go out and hunt all those SS-23s, you must first make sure that your AWACS stays alive. About 10 minutes into the mission, the enemy will launch a massive, brute force attack on the AWACS. It will consist of 3 waves of 2 flights each, 1 wave will approach the AWACS from due South, the other 4 flights will approach from the South-East. In repelling that attack, you will also knock out 4 of the target flights (SHAR4-6 and GHAALI6).

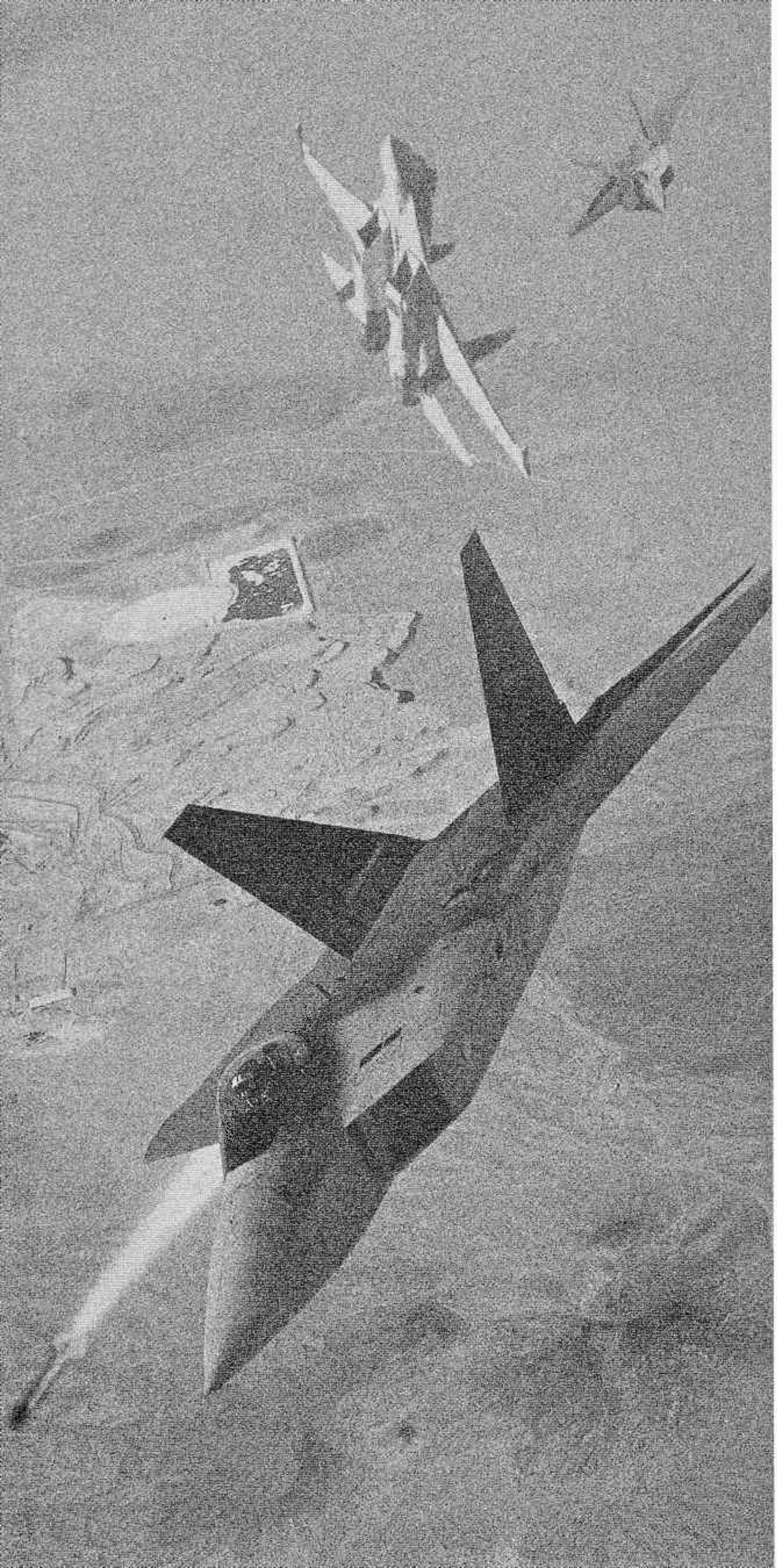
With those threats gone, the rest of the mission becomes actually rather easy. For the A2A part, just push your way south through the enemy forces and eliminate everything in the process. Sooner or later, the way to the A-50 flight (the enemy AWACS) and its MiG29M escort will be clear and they can be moved off the board.

With that accomplished, this AWACS mission becomes pretty free of pressures except for the lone 'must not' point regarding the enemy transport flight and which is not too difficult to take care of, just shoot down any ANT-70 which dares to come up. You can now concentrate on eliminating the SS-23 threat. Due to the fact that most of the SCUDs are rather cleverly positioned close to steep mountainsides or inside cities and towns, getting them all will probably require you to jump into the cockpits of several CAS configured F-22s, the AI-piloted strike flights sometimes fail to find them. Although there is no way to discriminate between those SS-23s which constitute mission objectives and those which are not, you will have enough firepower to get them all, so it does not really matter if you kill a couple of less important SCUD launchers during the course of this mission.

Chapter 9

Sailing through the Red Seas

- The Ethiopian Tour
- The Egyptian Tour
- The AWACs Tour
- The Saudi - Yemen Tour



CHAPTER 9

Chapter 9

Sailing through the Red Seas

If you have bought the Red Sea Operations expansion disk, you have four more tours of duty to play with - three ordinary F-22 tours and one AWACS-only tour – 36 missions in total. As with the original ADF Tours of Duty they are presented in order of difficulty.

Although the RSO tours usually present a more balanced force ratio compared to the original three TODs (hardly any 'you against the world' type of missions and almost all of them were designed to be accomplished without having to resort to the use of rearmament), they can by no stretch of imagination be called easy.

You will need to constantly think ahead, evaluate whether a particular enemy flight really presents a threat to your mission or can safely be ignored and last but not least, you will have to use and rely on your wingmen much more than you had to in the ADF TODs. However, the good news is that failure in a particular mission does not mean you cannot access the following missions, in RSO you can access each mission irrespective of your progress so far.

The RSO tours have other differences from the original F-22 ADF tours that are worth a little explanation. Within the limits of a scripted system they were designed to follow a logical order of progression and as such the 'war' will actually progress. You will be able to see this in the tours as ground occupation shifts and enemy air defence coverage is pushed back. Another difference is the logic used in the actual structure. With any war as you progress and are successfully prosecuting the air campaign, resistance will gradually dwindle until you are in a position to deliver the 'killing blow'. In the RSO tours this means that the missions will be generally harder at the start and get easier as you advance.

Victory conditions or more accurately Completion Conditions also require a little elaboration. As you will also see in the TAW campaigns, the Completion Conditions can appear a little strict. This is a limitation of the simulation's internal logic and therefore what may seem as pedantic goals is more than likely the result of much head scratching and ingenuity in order to create a realistic feeling and playing mission within such limitations.

As you may have experienced, many of the RSO missions can last several hours and you may even feel that the restricted availability of JADAMs is unnecessary. The reasons for this are twofold. Firstly dumb bombs and LGBs rely on player skill to deliver, secondly, they give you the freedom to play the missions as you want to. This allows you to fly some of the larger missions with your own goals and objectives, which may have nothing to do with the tour or original mission brief.

Patched or Un-Patched ADF

Although the RSO tours work with both the original ADF and the patched ADF there are some subtle differences that you may wish to explore on a cold winter's night. In general under the patched ADF the RSO tours play a little easier. This is due to the tweaks to both allied and enemy countermeasures performance that were applied in the patch. Other considerations include the modelling of blast damage, refined missile damage for AIM-9Xs and AIM-120s and realistic enemy ammunition loadouts (full details can be found in the technical section of the Hardware Chapter 13). The bottom line being, if you fancy a rough ride in RSO, try them with the original, unpatched F-22 ADF.

If you have been running RSO under the patched version of ADF you may have been unlucky enough to have had some of the original simulator missions overwritten by a duplicate copy of the RSO tours. There is a free patch on the Sim Tech website (www.sim-tech.co.uk) that will restore your simulator missions and leave the new RSO tours unaffected.

Part I The Ethiopian Tour

Since there is no sign that Ethiopia is willing to resolve the conflict through peaceful means, the United States have begun to reinforce their forces in southern Saudi-Arabia despite General Mortiega's threats that he would regard any move to strengthen the U.S. presence in the region as a hostile act. With the reinforcements on the way, it is expected that hostilities could commence at any moment without further warning.

Mission 1

Deployment

Mission Type

AWACS

Mission Objectives

C5-B Galaxy flight SLIP1 must pass over (its) waypoint 5.

C-17 flight RILEY1 must pass over (its) waypoint 5.

C-130J flight HERKY1 must pass over (its) waypoint 5.

C-130J flight HERKY2 must pass over (its) waypoint 6.

C-130J flight HERKY3 must pass over (its) waypoint 6.

KC-135 flight TEXACO1 must survive.

KC-135 flight TEXACO2 must survive.

Mission Description

In this mission, you will have enough forces to handle the enemy air threat, they are just in all the wrong places. Thus, your main job is to reposition your forces to be in the right place at the right time to meet the threats.

Since all enemy fighters will originate from either Ethiopia or Yemen, the easiest way to prevent them from interfering with your reinforcement effort is to bottle them up in the Southern Red Sea. To accomplish this, your should start to reassign CAP areas and Escort tasks as soon as the mission starts. Strip the JSTARS, AWACS and

refuelers of their escorts, and order the tankers closer to the action. Since a couple of the fighters have already been airborne for quite a while, they will soon start to call out for vectors to the tankers.

After the initial moves, wait for the enemy to come out. Although it is possible to win the mission without jumping into an F-22 cockpit, it will probably be easier to win if you do. You can also get the neutral forces to give you an (unintentional) helping hand. Though they are not inclined to start shooting themselves, they will defend themselves if attacked. Since the enemy planes do not seem to care what they fire upon, they will engage the neutral forces. With a bit of cunning manoeuvring, you can drag a couple of enemy flights towards the neutrals and get them to do your work (or at least a part of it).

Mission 2

Escort Recon flight

Mission Type

Escort

Mission Objectives

U2S flight CAPON1 must pass over (its) waypoint 13 (i.e. land).

U2S flight CAPON2 must pass over (its) waypoint 13 (i.e. land).

You must pass over waypoint 7.

Mission Description

Although the escort mission tasking usually implies defence against airborne threats, you are also responsible for defending the U2s against SAM and AAA sites. And if that was not already difficult enough, you will also have to race against both time and the ever decreasing level of fuel remaining in your tanks.

In order to minimise the time you need to get off the ground, time-skip to the runway as soon as the mission starts. Open the throttle all the way, takeoff and leave the throttle fully open. Since the U2s have taken off long before you, you will have to catch up with them before they get too close to the threats. However, you cannot afford to fly all the distance on full burner because you would run out of fuel despite the external tanks you are carrying. You can stay on full burner until your drop tanks are empty, at this point, you should throttle back to just a hair over full military power (and do not forget to drop the empty tanks, you really do not need the additional drag).

On your way to catch up with the U2s, you will have to handle one lonely SA-11 site and a couple of fighters. Once you have the U2s on your radar, there will be a couple of additional SAM sites threatening the spy planes, which you will have to take out. However, not all SAM sites constitute a threat to the U2s, and since you are not exactly

lavishly equipped with anti-radar missiles, make sure you do not waste them on 'harmless' SAM sites.

Apart from the SAM threat, you will have to intercept a couple of fighters both near the rendezvous point and on the way back. Although a couple of F-15s are supposed to help you on the return leg, they usually do not get all the fighters and you have to handle the ones they do not kill.

Once those fighters are gone, you just have to ensure the 'pass over' completion conditions are met. For the U2s, it means that they have to land at Jizan (which will take quite some time), and you have to pass the waypoint before your landing base to meet the conditions.

Mission 3

Air Superiority

Mission Type

CAP

Mission Objectives

MiG-35 flight KHALAZ1 must be destroyed.

Rafale flight TIGER2 must be destroyed.

MiG-29M flight KHALAZ5 must be destroyed.

F-22 flight IRON2 must pass over waypoint 10.

Mission Description

As in the previous mission, the 'mission type' is a bit misleading. Although it is a pure A2A mission this time, you will have to conduct a fighter sweep through enemy territory rather than 'capping' around over some fixed point.

Until you are past waypoint 3, the mission is quite uneventful. Between waypoint 3 and 4, you will meet your first targets, the MiG-35s. But since an allied F-14 flight is also cruising in the vicinity, they might actually do your work before you have a chance to close within missile range.

At this point, your next targets, the Rafales, should be closing in from about 9 o'clock, but you will usually have to take care of the Su-37 CAP before you can engage the Rafales, the Su-37s seem quite keen to meet your flight.

After you have taken out the Su-37s and the Rafales, you can either continue with your flight plan or start to head back home again – your last targets, the MiG-29Ms will make their appearance between waypoints 2 and 3. However, since they do not takeoff before 7 o'clock, you might actually have to kill a couple of minutes converting jet fuel into heat until you can finally tackle your last task.

Mission 4

Operation Titanic

Mission Type

AWACS

Mission Objectives

3 Avenger groups must be destroyed.

SES group must be destroyed.

Mission Description

As AWACS commander it is your job to ensure that the Harpoon bearing Strikers get through to their targets and pulverise the blockade. To accomplish this task, you will have an ample supply of both fighters and Harpoon armed strike flights. The only two snags are that a couple of the fighters will need to refuel again and that the enemy might try to kill your JSTARS plane.

To handle the first problem, move one or two refuelers down south towards the engagement area, the closer to the action you refuel the fighters, the faster they are back in action. To counter the threat to your JSTARS plane, just move it a bit away from the border and order the F-15 CAPs in the vicinity of the JSTARS to engage the Rafales just across the border.

With these problems out of the way, proceed with the main task. Order your air-tasked fighters south and establish air supremacy over the target area. Next, wait for the strikers to come in and order them to destroy all enemy ships – you do not really have to distinguish between the enemy groups which are your mission targets and those which are not, you will have enough strikers to sink all ships. As soon as the last one has slipped below the surface, the success box will come up.

Mission 5

LGB Attack

Mission Type

Interdiction

Mission Objective

Naval HQ must be destroyed.

You must pass waypoint 10.

Mission Description

Your task for this mission is to destroy a Naval HQ rather deep within enemy territory. The HQ building is located in the middle of a cluster

of buildings and does thus not exactly stand out. Therefore, take a good look at the target photo before you enter the cockpit to be sure you will be able to make out the right building over the target area.

This is one of the missions in which using the F-22's stealth characteristics can go a long way to make your life easier – in fact, done right, you can get through the whole mission without firing a single A2A missile.

After takeoff, fly towards waypoint 2 following your flight plan. At waypoint 2, forget about the preplanned route and proceed directly towards waypoint 6. On the way to waypoint 6, you might have to take a slight detour once or twice to avoid a SAM site, but that is about it in terms of enemy opposition. Although there are a couple of enemy fighters airborne, other allied flights and your escort ought to be enough to handle them.

As you come up on the target, you will note that there is a SAM site deployed right next to it. Although the idea of putting your head down into the cockpit to guide the LGB whilst some enemy gunners are trying to blow you out of the sky sounds a wee bit dangerous, there is a way to pull it off.

You might have noticed that the F-22 will not be painted by enemy SAM sites at certain angles, and we will use this advantage in this mission. Instead of flying directly towards the target, turn a bit either left of right so that you get about a 10 degree offset. This should be enough to make you invisible for the enemy SAM radar, and you can concentrate on destroying the HQ building (you do remember which one it was, don't you?).

After your primary target is destroyed, you can proceed towards home. However, since you are carrying two LGBs, there is a nice, completely undefended enemy oil rig about 25 miles south of waypoint 8, practically on the way.

Mission 6

Counter Air

Mission Type

Fighter Sweep

Mission Objectives

C-130J flight AL_JUMA3 must be destroyed.

ANT-70 flight AL_JUMA4 must be destroyed.

ANT-70 flight AL_JUMA5 must be destroyed.

C-130J flight AL_JUMA6 must be destroyed.

C-130J flight AL_JUMA7 must be destroyed.

You must land at Jizan.

Mission Description

Well, Intel has not uncovered yet who this Al Juma guy is, but he is about to have a very bad day. As in the previous mission, the easiest way to accomplish this mission is to rely on the stealth characteristics of the F-22 again.

After takeoff, proceed directly to waypoint 2. As you close on it, you should begin to see your first target flights, unfortunately pretty much surrounded by enemy fighters. However, by careful manoeuvring it is possible to 'thread the needle' and to get to the targets without drawing the attention of the enemy fighters.

Apart from avoiding the fighters, the order in which you tackle the transports may have a significant influence on how the mission unfolds. The easiest way is to concentrate on the two Antonov flights first and to leave the Hercules flights for the time being. One of them (AL_JUMA6) usually gets killed by allied fighters anyway, whilst the other one proceeds merrily out of the area in which it is covered by enemy fighters.

Back to the Antonovs. Depending on how long it took you to dispose of them, you will notice that one target flight is still missing – it is the last Hercules flight (AL_JUMA7). It is not airborne at the start of the mission and will take off from Mersa Gulbub at around 7:25. Since you are probably still in the neighbourhood of that airfield after you have destroyed the Antonovs, you should stick around until the Herkys become airborne.

After you have removed the freshly airborne Herkys, proceed to intercept whatever is left of the other two Hercules flights.

Try to be done with everything (or at least out of enemy airspace) before 7:45 – at about this time the enemy AWACS comes up and all the fighters which have been more or less blindly circling around will suddenly become a lot more dangerous.

Mission 7

AWACS Kill

Mission Type

HVAA Kill

Mission Objectives

A-50 flight SHAZAM1 must be destroyed.

You must land at Jizan.

Mission Description

Although the mission briefing would suggest otherwise, this is actually a ground attack mission – the AWACS you have to destroy is sitting on the ramp of the Balul airbase. However, it will not be defenceless, the airbase is quite heavily defended by SAMs and AAA.

The mission itself will be rather uneventful until you are about halfway to waypoint 3. At this point, the enemy CAPs will finally notice you, and a flight of MiG-21s and a flight of Su-27s will turn in towards your flight. Your escort will have no trouble to handle the MiGs, but you will probably have to send one or two missiles in the direction of the Su-27s yourself to discourage them.

Once those two groups of fighters have been eliminated you should have a free run towards your targets as far as enemy air threats are concerned. However, as you come up on the target, you will note that there are indeed quite a few enemy air defence units deployed. On the other hand, between yourself and your wingmen, you have enough A2G missiles in the form of AGM-88 HARMs and AGM-65 Mavericks to eliminate all of them.

Once you have created a lead free zone of airspace above the enemy airbase, you just need to locate the AWACS plane and destroy it. And although there are quite a lot of other, worthwhile strafing targets left, it is best that you leave the scene of the crime as soon as you have destroyed your primary target. If you overstay your welcome, you might find yourself in the middle of a couple of enemy CAPs just taking off.

Thus, head home and relax – if you have not dragged your feet, the egress should be a quiet one.

Mission 8

CAS Support

Mission Type

AWACS

Mission Objectives

You must destroy 5 T-80 groups.

You must destroy 2 BMP3 groups.

You must destroy 3 SA-6 groups.

You must destroy 5 ZSU-23/4 groups.

Mission Description

This mission is a lot easier to accomplish than the long list of enemy armour and air defence units you have to destroy would suggest. The enemy air threat is negligible, and you will get enough CAS flights to do the deed.

The first thing you need to do is to locate your targets, and there are two ways to do that. In the AWACS, click on the army button and note the positions of the enemy armoured groups. Next, note all air defence units surrounding those units and voila, one target list. The second way to get all the targets is to jump in an F-22 cockpit, all targets you need to destroy are within the killbox displayed on your situational MFD. Now that you know what you have to do, let us go to work.

As with most other AWACS missions, a multi layered approach works best. Although there are hardly any fighters up, the few which are circling over the targets could interfere with the attack. Thus, remove them first. You do not need to worry about the other enemy CAPs further away – since the enemy has no AWACS up, they will not notice what is going on beyond their sensor range.

After the fighters are gone, concentrate on the enemy ADF units. Usually, CAS tasked planes tend to work after the 'One pass – haul ass' principle. Thus, your main job in the AWACS will be to convince them to continue with the attack as long as they have ordnance left. The same goes for the attacks on the enemy armour columns once the ADF units are gone – keep on reassigning targets for the strike flights as long as they have ordnance left.

Depending upon how long it takes to destroy all ground units, you might have to refocus on the air picture again. After a while the enemy launches an AWACS-Kill mission consisting of 2 flights of 2 MiG-29Ms and 1 flight of 4 Su-35s. If this constellation appears on your screen, make sure you assign enough fighters to handle the threat.

However, apart from that small problem, the mission is quite doable, it is actually one of the few AWACS missions which can be easily won without jumping into an F-22.

Mission 9

Deep Strike

Mission Type

Interdiction

Mission Objectives

Container ship group must be destroyed.

You must land at Ash Sharawrah.

Mission Description

For this mission, the character trait you will need most is discipline. Though you will pretty much have to wade through enemy fighters both on the inbound leg and the egress, you must resist the temptation

to enter the fights around you unless it is absolutely certain an enemy fighter has targeted you and cannot be avoided.

Until you are close to waypoint 3, the situational MFD might look interesting, but there will not be much happening in your immediate vicinity. As you come up on waypoint 3, the enemy fighters will begin to close on you and your not exactly small and inconspicuous group. However, there should normally be no need to get into the action yourself, your escorts and the other allied flights should be able to handle the threats. Depending on how the air battle unfolds, you might want to skip past waypoint 4 and proceed directly to waypoint 5.

After you have passed waypoint 5, you will note that your target is rather heavily defended, but you will again get some help from the other allied flights which should kill a good number of the deployed ADF units. If any remain close to the target, you and your wingmen have got 2 HARMs each with which you ought to be able to take out the ADF units which might interfere with your bomb run.

For the bomb run itself, it is usually helpful to know which target you have to destroy. Although the briefing states you have to kill a 'Containership Group', this group has exactly one member, it is the ship closest to the coast in the harbour (which is, incidentally, why you have iron bombs, the second ship is acting as a 'Harpoon screen'). You should strive to hit it on the first pass and to get out immediately again – there are a lot of enemy fighters converging on your egress route. If you work fast, you should be able to slip past them without too much trouble (except for one or two really obnoxious ones). If you spent too much time working the target over, you might find your exit route squarely blocked by enemy interceptors. However, if you are into dogfights, you might actually like that development – well then, have fun.

Mission 10

Final Kill

Mission Type

Decapitation

Mission Objectives

Hardened Hangar must be destroyed.

Ant-70 flight AL_JUMA4 must be destroyed.

You must pass over waypoint 13

Mission Description

The ingress for this mission is pretty uneventful and can be wholly flown on autopilot, except for one short section where you have to

sneak past a chain of SAM sites. As you come up on the target, the AL_JUMA4 flight should be still on the ground, but just barely. Take out the hangar on your first pass (set the salvo size to two as you need to hit the hangar with both bombs to destroy it) You should also note that, since you carry the bombs internally, there will be a slight lag between your trigger press and the bomb release since the bay doors have to be opened first. Thus, do not release the bombs in a shallow dive, rather use a steep diving angle where the impact marker will not rush past the target in the time between the trigger press and the actual bomb release.

Once the hangar is destroyed, try to find the transport plane. Although the AL_JUMA4 flight consists of only one plane, there are a couple of other transports parked, taxiing and taking off, which might make it a bit difficult to get the right one. When in doubt, blow them all up, that way you can be sure you will get the right one. However, you will not get them all before a couple of Su-35s takeoff which do not particularly agree with your intention to blow up the place, so you might have to stop shooting fish in the barrel to handle a real threat for a change.

If you are done with your work at the airbase, do not waste any time and get out. The way back is more or less a reprise of the ingress, except for the chain of SAM sites you have to tiptoe past, it should be quiet again.

Part II The Egyptian Tour

This tour sees a sole wing of 36 F-22s along with support in the form of AWACS, JSTARS, KC135s C130Js and 1 EC130, supplement a modern Egyptian airforce which has no F-22s of its own. The deployment was almost complete and the allied forces were preparing to launch the full scale Southern air offensive when the Sudanese unexpectedly launched a series of surface to surface missile strikes against the border Egyptian bases. With the initiative firmly with the enemy, allied forces are forced to withdraw and regroup. Initial missions see you acting as second line defences to prevent Sudanese gains, followed by a supporting role in the drive South and finally the decisive act to bring the conflict to a conclusion.

Mission 1

Relocation

Mission Type

Fighter Sweep

Mission Objectives

Flight ASHRA1 A-10 must have survived.

Flight ASHRA2 A-10 must have survived.

Flight Magic1 E-3 must have survived.

Flight Carpet E-8 must have survived.

You must land at Mina Baranis.

Mission Description

This is basically a scramble mission with a couple of twists. It requires you to be able to act quickly, assess the immediate threats and respond rapidly without hesitation. Finally you need to be able to know when to call it a day.

The surface to surface missile threat is very real and your base will take a direct hit within 50 seconds of the mission starting. Therefore, do not linger on the pan, manually taxi as soon as you can to the threshold. If you take your time and the tent behind you is hit, it is

likely that you will sustain some collateral damage, and the loss of afterburner, for example, would severely hamper you in this mission.

In this mission you have to relocate to Mina Baranis airbase, but before you can do this two flights of A-10s, ASHRA 1 and 2 have to return to their base (only one aircraft from each flight needs to survive). After rushing to get airborne turn to a heading of 150 degrees, a quick check your MFDs will show that ASHRA 1 is close to an enemy CAP flight and could very quickly end up in a lot of trouble. The position of ASHRA 2 is safe for the moment, so make your priority the safe passage of ASHRA1 to its destination airbase.

You need to fly on full afterburner towards ASHRA1 in order to intercept the enemy CAP that is closing around him, you have external tanks, so fuel is not a problem at this stage. There is some friendly CAP in the general vicinity, but the enemy has some high class interceptors, which seem intent on having a party. Be aware of the high speed advantage of the MiG-31s and consider this flight a priority target.

Engage the enemy BVR and during the ensuing dogfight always be aware of the position of the A-10s and engage any aircraft that proves an immediate threat to these flights.

After a successful engagement, escort ASHRA 1 to its destination airbase and check the position of ASHRA 2. Check your fuel status and proceed to your destination airbase, get down low, set your EMCON to manual 1 and avoid any unnecessary engagements. Depending on the timing of your arrival at Mina Baranis, there will be an enemy strike flight heading in your direction. You can either land and end the mission or refuel/rearm and engage the incoming strike flight which now threatens your new base.

Mission 2

Dam Defence

Mission Type

Combat Air Patrol (CAP)

Mission Objectives

You must kill flight INTEEN 3 Su-34.

Dam must not be destroyed.

Flight Magic1 E-3 must have survived.

You must have landed.

Mission Description

A standard CAP over the biggest dam in Egypt. Acting as the last line of defence, you need to be judicious in your use of missiles or create

time in which to land and rearm. Although the briefing mentions a particular flight that must be destroyed you must also ensure that the dam is not breached. The key to this mission is not allowing yourself to become fixated with finding flight INTEEN 3, since they will come to you, at least they will if you are protecting the dam.

You start on the runway and after a quick check of your flight settings blast off and head for your patrol circuit. Despite the protestations of the AWACS you should avoid contact with flight KWAYYIS3, a pair of Su-27s. If you use 'Time-Skip' you will not have a choice, so for the transit leg it is best to use 'Time Accelerate' or fly on normal time.

Throughout the mission avoid being drawn too far South. Although at times it will be wise to help the Egyptian CAPs, you should do so from a distance. Careful monitoring of the inbound enemy flights will reveal tight formations that appear to be just a couple of aircraft to a cursory glance at the MFDs. However, several of the flights are 'stacks' of 4 or more aircraft, as they close on their IP's the flights will split into their respective components (Escort or Strike) and this is your opportunity to down as many Su-34s as possible. The other reason for not straying too far South is so that you avoid the 'sucker punch' delivered by a flight of MiG-27s. This flight picks its way in around the SAMs from 250 degrees and subject to the competency of the Egyptian SAM crews all 3 could make it through to the dam.

Mission 3

Operation Blackout

Mission Type

Deep Strike

Mission Objectives

EWR Control building must be destroyed.

EWR Control building must be destroyed.

Dome Comms building must be destroyed.

EWR Control building must be destroyed.

You must land at Wadi Halfa.

Mission Description

This is perhaps the longest mission in RSO. It is the only one that almost certainly requires rearming (only the hottest pilot can complete it in one hop) and it is also one of the missions that you could use simply for fun.

The mission requires the surgical removal of the enemy's Northern chain of EWR sites without involving a co-ordinated strike package of other aircraft. Utilising the F-22's stealth capability along with its enhanced avionics, it is hoped a pair of F-22s can run along the chain,

virtually undetected, and knockout the Northern EWR coverage before the first massive daylight raid of the campaign. At the same time F-22s will attack the enemy's airborne A-50 AWACS to complete the blackout.

By eliminating this defensive screen a window of opportunity will then exist for further Strikes against an enemy without operational air or ground EWR.

You will need to study the briefing map and examine closely the position of the targets and the waypoints that immediately precede them. These are waypoints 2, 4, 6 and 8. It is by careful adjustment of these waypoints on your Situation MFD whilst en route that will keep you out of much trouble as possible during the mission.

During the mission you will have to keep your aircraft in almost 100 percent working order, any engine or airframe damage will seriously reduce your overall chance of success. If you should suffer a fuel leak then due to the distances involved to and from the targets you have as good as lost the mission. Most of the mission should be flown under 500 feet in Manual EMCON1 unless a combat situation develops.

Whilst en route to the first target at waypoint 3 you will see a friendly flight of Rafales, Mirages and MiG-21 aircraft who are heading in your general direction. Manually fly towards them or move waypoint 2 so that it is somewhere in their general direction. Hang back and let them engage the first CAP of MiG-29s, MiG-21s and MiG-27s that you see up ahead. Always remember during this mission to try and resist the temptation to engage any enemy flights, unless you are certain of a 100 percent kill rate or you have been locked up and have no option but to fight anyway.

At the first target, get your wingman to target the SAM/AAA but try and leave the SA-17 for yourself as a 'guns kill'. When the area is clean of SAMs/AAA take out the first EWR site with your Mk 83s. Follow waypoint 4 and then head on over to Target 2 at waypoint 5.

Whilst en route to the target you should encounter a Ka-50 Hokum which should prove to be any easy guns kill, do not waste a missile on a chopper. Keep a close eye out for any CAP and move on to the EWR site, eliminating the SAM/AAA sites immediately surrounding the target with your Mavericks.

After a successful bomb run on Targets 1 and 2, adjust waypoint 6 so that you will be heading back towards your own border where there are plenty of friendly CAPs to cover your behind. Dump any A2G stores and providing you can weave a route without coming too close to any enemy CAP, head on over to waypoint 10 (Wadi Halfa) for a rearm and refuel.

It is up to the individual pilot at this stage in deciding his refuel/rearm base, waypoint 10 (Wadi Halfa) is closer to the two remaining targets

(see the briefing map), but circumstances may force you to choose another base. If you ask for a vector approach to the airbase and you still have your wingman at this stage, remember that due to a limitation within the simulation your wingman will land and taxi to the ramp thinking that the mission is over rather than rearm. Once you have refuelled and rearmed you need to plan you route into the remaining targets.

The EWR site at waypoint 7 (Target 3, Dome Comms. building) is located in a valley, and of the 4, is the most difficult to hit. In addition to the SAM/AAA units located in the immediate vicinity of the target, there is a unit strategically placed on the ridge of the valley overlooking the target area.

Depending upon your timing at this stage in the mission, either of the two remaining EWR sites is a viable option. Your choice should be dictated by the amount of enemy CAPs within the vicinity of the target area and whether there is an allied strike package heading in the general direction of either target, which will take some of the heat should you get bounced en route.

Due to the number of SAM/AAA units and being loaded with only 2 Mavericks, you may wish to visit Target 3 a couple of times, just to be on the safe side. You should also be aware that, due to the blast modelling of the Mk 83s since the patch, if you are down too low, trying to avoid the unit on the ridge, you could suffer blast damage from a low delivery on target, which may prove to be crucial at this stage.

On any return journey to Wadi Halfa airbase always remember to jettison any remaining A2G stores to help reduce your Radar Cross Section (RCS) and make you more stealthy. All that now remains is for you to apply the previous tactics to the last remaining Target (4) at waypoint 9, and the mission will be a success. Figure 1 shows one method of completing Operation Blackout.

Figure 1

Mission 4

Divide & Conquer

Mission Type

SEAD and Counter Air

Mission Objectives

Control Tower must be destroyed.

You must pass over waypoint 5.

You must have landed.

Mission Description

A huge Allied strike force has been co-ordinated for this mission, as you will see from your MFDs whilst en route to your CAP at waypoint 5.

At this waypoint there are a number SAM/AAA threats that should be eliminated so that you do not have to worry about any surface threat while carrying out your CAP role.

You can now treat this waypoint as a 'Safe Area' and central point from which to conduct your A2A operations. Return to it after any engagements and reasses the situation, consider the most lethal threats. By careful forward planning you should be in a position to help out any strike flight that may run into trouble. You should expect Scrambled Alert fighters from Atbarah itself, but be wary of straying too close to the local air defences.

Keep a watch on the mission goals, although the tower may be targeted by several flights, you can guarantee success by ensuring that flights SITTA 4 and 5 make it to target. If the area is clear of any A2A threats, you should be able to watch the strike flights going in against the airfield.

Mission 5

Logistics Strike AWACS

Mission Type

AWACS

Mission Objectives

You must kill flight AL_INTEEN 1 IL-78R.

You must kill flight AL_JUMA 1 ANT-70.

Mission Description

As AWACS commander for this mission you must see that flights IRON 4, 5 and 6 get to the target airfield, 'Bur Sudan', without interception. These flights are critical to the mission's success and therefore must be protected at all costs.

Try to bring as many allied CAP flights to the Sudanese border as possible, in preparation for the big push when IRON 4,5,6, start to enter enemy airspace. You may wish to adjust the flight paths of IRON 4, 5 and 6 to buy some time for your support flights to catch up.

When the allied Strike flights are on their way to the target airfield, start sending the previously mentioned allied CAP flights to intercept the enemy flights along the main strike flights route. A number of the

enemy aircraft are returning to Bur Sudan as the mission brief has indicated and are mission goals, so make sure that they are destroyed.

If you find yourself short of friendly CAP flights, look to see whether the E-3 and E-8 have escort flights. If they do, then disengage one of the escorts and send it to wherever you want, then move the E-3 and E-8 closer together so that they will both be covered by the remaining Escort flight.

You will notice that IRON 4, 5 and 6 are F-22 flight so this is an excellent opportunity for you to fly each stage of the attack mission. As you get closer to the target airfield of Bur Sudan, jump into the F-22 that has been tasked with the Wild Weasel Role and take out any SAMs/AAA as well as air threats surrounding the target area. Next try the Mobile Strike/Strike aircraft and take out the mission targets.

Keep a close eye out for and engage any enemy flights that may have survived the earlier skirmishes and are still making their way towards Bur Sudan in order to land. Subject to timing, you will either be able to destroy the ANT-70 and IL-78R on the ground or, if air defences are still intact due to poor performance by the WW flights, you can wait until they take off and leave the security of local air defences.

Mission 6

Downtown AWACS

Mission Type

AWACS

Mission Objectives

You must have killed 3 T80 groups.

You must have killed 2 BMP3 groups.

You must have killed 2 G6 groups.

You must have killed 1 BRDM-2 group

Mission Description

It now becomes apparent why it was necessary to save the A-10s in the first mission. The push into Sudan has encountered fierce resistance and to avoid the dreaded Fighting In Built Up Areas (FIBUA) for Egyptian ground troops, it is time to use air power to bust armour. There are several ways to play this mission. Though you only have a wing of 36 F-22s in theatre several of them will be deployed in this mission. Their roles will be split between CAP, CAS and SEAD therefore, it will be possible for you to pull yourself out of the comfy chair to mix it up in Northern Sudan. Indeed, any F-22 equipped with HARMs should be vectored towards Dunqulah to help soften up the defences.

From the AWACS Commander's screen you will need to switch on the 'Army' button to see where the enemy's ground forces are located. You will see that there are a large number of ground forces from both sides preparing for a land battle in this area, so there is a high possibility that the enemy will be sending strike flights against your ground forces too.

Your will therefore need to establish air superiority, so move as many CAP flights into the target area as soon as possible.

Your flights will soon start to assemble and by clicking on the 'Routes' button you will see the large number of allied aircraft that have been tasked for this mission. If engaging any enemy aircraft over the battlefield area, always be aware of the SAM/AAA threat, especially if it is early on in the mission. Do not hesitate to re-task any strike flight towards the battlefield area, (always bear in mind the mission's objectives) in order to help whittle down the enemy's forces.

When the scenario is well under way, zoom down to the battlefield area and watch your strike flights carefully as some flights may be returning to base with weapons still on board, especially the A-10s (remember the A-10 is the only allied aircraft that will strafe ground units). If this happens, select the flight and order it to strike the targets again by dragging the pointer over the enemy target icon. If a particular flight's target has been destroyed, then continue to select another target for the flight, until the AWACS commander's view information window indicates that the selected plane is now 'Unarmed'.

By adopting the aforementioned tactics you should soon see the enemy's ground forces start to diminish. The mission success window will appear to indicate the scenario is won as soon as the last of the targets has been destroyed.

Mission 7

Armour Busting

Mission Type

Battlefield Air Interdiction

Mission Objectives

You must have killed 7 BMZ groups.

You must land at Wadi Halfa.

Mission Description

Your first priority during the course of this mission is to eliminate the enemy CAPs that surround the target kill box. With the enemy CAPs out of the way the SAM/AAA threat should be next on your list.

Again, watch for any allied support flights that are making their way towards the general target area and leave them to take the brunt of the initial strike.

Next remove the SAMs surrounding the target area and do not forget to assign your shoot list to your wingman. The local SAMs/AAA are concentrated in three positions. There are several in the Eastern outskirts of the town, a pocket in a small depression North and another in a similar depression to the South. A further group occupies a potential egress route further East. It is important that you destroy all the SAMs/AAA before you hunt the BMZ launchers, since it is likely that you and your wingman will need to make several low speed passes searching for the last few targets. With 12 Mavericks between you and your wingman, you have plenty of ordnance for dealing with the SAMs/AAA.

The target enemy mobile ground units will be making use of the cover provided by the buildings of Al Khandaq town, which is located in a valley. Bear in mind that due to a glitch in the program, sometimes you will be able to lock up a target which is in fact behind a building, so check its position before letting rip with your precious A2G Stores. Try to asses which of the mission targets are close together and which are on their own. Use cluster bombs on the units that are tightly grouped saving your LAUs for picking off the single units, or if things have not gone to plan, you have your 20mm gun to fall back on.

Mission 9

Airfield Strike

Mission Type

Interdiction

Mission Objectives

You must kill flight ASHRA2 Su-25.

You must kill flight ASHRA3 Su-25.

You must kill flight AL_JUMA ANT-70.

You must land at Wadi Halfa

Mission Description

The airbase at Merowe is well defended, so check out your Situational MFD whilst en route and assess the SAM and CAP threat in and around the target area. As always, use the tactic of letting any allied strike package precede your flight if they happen to be going in your general direction.

You have a flight of F-22s (callsign IRON5) which will act as Wild Weasel support for this mission. They will generally stick with your

flight, should any flight plan deviations occur, do not be afraid of losing them. They will, however, go their own way towards the target airbase once the IP has been reached.

Next, eliminate any immediate Surface-To-Air threat.

The geographic position of Merowe is on a plateau with a valley running around it in a semicircular route. Go to Manual EMCON 1 and fly back and forth along the previously mentioned valley floor, (providing it is clear of any SAM/AAA threat). Use this method whilst looking for targets and order your wingmen (you have 3) to engage as many of the enemy CAP and SAM/AAA as possible.

If the enemy starts shutting down his SAM sites, 'pop up' from the valley floor, go to a higher EMCON level and entice the SAM operators with a nice big target, but stay over the valley and be prepared to get down low again as soon as the SAMs start to come back on line.

The enemy AAA is deadly and will bring down your plane as surely as a SAM, so try and eliminate as many of the surface-to-air threats as possible before commencing your attack against the enemy planes on the ground.

Mission 9

Scud U Like

Mission Type

Combat Air Patrol

Mission Objectives

8 SS-23 groups must survive.

Allied Rafale flight TIGER1 must fly over waypoint 4.

You must land at Wadi Halfa.

Mission Description

This one of those missions that combine a high pucker factor with the stress of constantly monitoring a small, dynamic environment. To accomplish this mission you also need to utilise your wingman efficiently and control your fuel reserves.

The most efficient way to actually executing the mission is to fly a circuit opposite to your waypoint route. You can ignore the first flight of MiG-27s heading for waypoint 4, they are merely a diversion and will soon peel off to attack other targets. Although you will meet flights of Su-27s and MiG-29Ms as well as some enemy SAM sites, it is important that you deal with the more potent threats while you have the time to plan the fight.

Use altitude and speed to extend your missiles range and initially use only your AIM-120Cs, save your AIM-120Rs for when you need their extra legs to down a distant target closing on the SCUDs. Get your wingman involved first, using his missiles while conserving your own. His AIM-120Rs are almost 1 shot 1 kill so you should be able to wipe 3 Su-27s and a MiG-29 from the board early on.

Using supercruise and altitude, fly a circuit around the SCUDs and clear the air of anything that could pose a threat. By using the IRST display, you can see the loadout of the individual aircraft that you target. Anything carrying 'brown bombs' should be a priority target. Between yourself and your wingman you are carrying 28 missiles, more than ample to deal with the threat. As long as you do not waste ordnance on low PK shots you should have no problems. Try and save two AIM-120Rs for the final section of the circuit, due South of waypoint 4. By sending these towards the fighter cover of MiG-29Ms you will have an easy ride dispatching the 3 MiG-27s and 4 Su-25s that creep in ahead of them.

Mission 10

Deep Throat

Mission Type

Escort

Mission Objectives

Allied flight SITTA 1 F-16U must fly over (its) waypoint 4.

You must land at AKORDAT DISPERSAL

Mission Description

After takeoff, locate the F-16Us and check their position on the MFD. You will have quite a long haul to your destination airbase at Akordat in this mission, so although you have to Escort and provide SEAD for the F-16Us, always keep an eye on your fuel status and avoid any knife fights with the enemy's CAP that will require use of your afterburner, try and take the enemy out BVR whenever possible.

Remember that your mission goal is to make sure the F-16Us get to waypoint 4, after that, clinically speaking, they are on their own, unless your sense of duty thinks differently.

You will be carrying Mavericks and HARMs for the SEAD role, so any threatening SAMs/AAA should be removed in order to give the F-16Us a better chance on their ingress and over the target area.

In this mission you will have to juggle carefully between the two roles of SEAD and Escort. If you want to succeed, always remember your mission objectives. Careful monitoring of your MFDs will ensure you react to any A2A threats to the F-16Us, and by cleansing the area around waypoint 3 of SAMs you should be able to break off.

When you have accomplished the SEAD/Escort leg of the mission, be sure to drop any external ordnance to assume a clean configuration. By switching to manual EMCON 1 you should be able to fly to Akordat Dispersal unmolested.

Mission 11

Decapitation

Mission Type

Decap

Mission Objectives

LIMO must be destroyed.

You must land at Akordat Dispersal.

Mission Description

The idea is to carefully pick your way in avoiding detection and then to sneak back out again once the deed is done. Therefore, the stealth capabilities of the F-22 will have to be used to their maximum for this mission and manual EMCON1 should be your setting throughout the flight due to the amount of SAM/AAA sites in and around the target area.

Should you be fired upon do not forget to raise your EMCON level in order for the on board Counter Measures to take effect if the manual dispersal of chaff and flares does not seem to have any effect

Your flight plan will drop you down to low level as you near the target area and a manual search will have to be made for the LIMO vehicle which you should try to take out on your first pass.

Due to the LIMO's position on a valley road you will not have much time to acquire and lock up the target, so adjust your speed beforehand. Make sure you have a clean shot, fire, and slip back into the darkness of the night.

If you want, do a quick cross check with the mission goals via the keypad DEL key to make sure the Limo has been destroyed.

Keep a close watch for any alert fighters that may be scrambled from the nearby airbase, so be prepared by selecting your AIM-9X sidewinders, but try not to get into a dogfight though, as the SAMs/AAA in and around this area will soon start tracking your F-22 and you could find yourself in a lot of trouble. Remember stealth is the name of the game.

Part III The AWACS Tour

The recent months have been remarkably quiet, but the current situation along the Saudi-Yemenite border can best be described as heavy silence – everybody suspects something is in the works, but nobody can prove it or even venture a guess about what will happen. Despite the warnings that something is brewing, the U.S. forces in the region have been reduced to the point where only a token show of force is all that is left. The most serious loss has been the departure of the last remaining F-22s to participate in an exercise in Korea. Yemen has waited for this moment - although you start the tour with peace still intact, things will heat up at an alarming pace.

Mission 1

Intrusion

Mission Type

AWACS

Mission Objectives

E-8 Flight CARPET1 must survive.

You must run out of time.

Mission Description

The goal of this mission is pretty easy to describe – try to survive it. Although the situation looks quite peacefully initially, the enemy will commence the attack shortly after you start the mission by launching flights to bomb the allied airfields close to the border.

However unnatural this might appear, do not try to interfere with these attacks, with the meagre assets you have, you cannot afford to fight secondary battles. This mission is about the survival of allied battlefield surveillance assets - your AWACS and JSTARS planes.

About 10 minutes into the mission the first wave of enemy HVA kill flights will take off, consisting solely of Su-37s. At this point, distribute your CAP flights evenly to attack the two groups and order both the AWACS and the JSTARS to head north.

When the enemy flights cross the border, focus on them by bringing them up in the small window to wake up the ground defences. If you are lucky, the combined efforts of the allied air defences and the CAPs will eliminate the first wave. Do not worry that things might become boring, the second wave of enemy AWACS killers should already be airborne. If some of your fighters have survived the fights with the first wave, order them to engage the second.

At about 8:30, you should finally receive some help by scrambled allied fighters – as soon as they are up, order them to join the battle. It is unlikely that you will be able to destroy all enemy fighters hunting your AWACS, but you will not need to.

The point is to buy enough time for both the AWACS and the JSTARS to retire so far north that they will be beyond the range of the Su-37s. You will notice that the Su-37s will turn back at some point and head south again, that's when you have basically won the battle. Officially, the battle will be over after 75 minutes, the success box should appear then.

Mission 2

Resupply

Mission Type

AWACS

Mission Objectives

Galaxy flight SLIP1 must survive and fly over waypoint 5.

Galaxy flight SLIP2 must survive and fly over waypoint 5.

Galaxy flight SLIP3 must survive and fly over waypoint 5.

Galaxy flight SLIP4 must survive and fly over waypoint 5.

Mission Description

In order for the supply flights to survive this trip, the airspace they enter must be absolutely free of enemy fighters - if an Su-37 gets just a sniff of a Galaxy, it is dead. For you as AWACS commander, this means you have to execute this mission aggressively and proactively.

For starters, strip both refuellers, the JSTARS and the AWACS of their escorts. Split the escorts evenly to cover the areas around both airfields and send them down South to act as the first wave. More fighters will become available, but you have to start reducing the enemy's numbers as soon as possible. Make sure that you refuel the fighters which ask for fuel, a couple of the flights tasked with TARCAP will definitely need it.

As more fighters become available, continue to assign them intercepts as soon as possible, and do not hesitate to commit the escorts of the

supply flights, they are of no use if they are shot down alongside their sheep.

This mission is actually relatively easy to win, provided you start your killing early, and once all enemy fighters have been eliminated, the success box will come up as soon as the last of the transport flights has passed its supply drop waypoint.

Mission 3

Counter AWACS

Mission Type

AWACS

Mission Objectives

You must kill A-50 flights SHAZAM1 and SHAZAM2.

Mission Description

With the immediate threat to our bases gone, it is time to teach Yemen a lesson. Since they tried so hard to kill our AWACS planes, we will return the favour.

Although two dedicated HVA kill flights are tasked with the actual AWACS kills, they won't get to their targets unless you clear the way long before they arrive.

Again, this means sending each and every fighter south, except for the lone EF2000 low on fuel and unarmed. In order to maximise the chances for the allied flights, you should try to organise them into wolfpacks, just like the German U-boats in WWII. Instead of assigning one allied flight to each enemy CAP, rather converge two or three allied CAPs/Escorts on an enemy CAP. After it has been taken off the board, reassign the surviving fighters to the next enemy CAP flight.

What will also help to maximise the chances for the allied HVA kill flights is to time their arrival carefully. This means that due to the extended orbits the AWACS planes fly, they will quite often place themselves between their escorts and the allied attackers, not exactly smart, but fact. If you see such a situation develop and order the HVA kill flights to intercept the AWACS, they will immediately accelerate to a much higher speed and might thus catch the AWACS in the vulnerable position described above.

The mission will continue until you have killed the both AWACS planes, and the success box will appear as soon as the second one has disintegrated into its component parts.

Mission 4

Paralysing

Mission Type

AWACS

Mission Objectives

B-2 flight RAID1 must pass over waypoint 6.

B-2 flight RAID2 must pass over waypoint 5.

B-2 flight RAID3 must pass over waypoint 6.

B-2 flight RAID4 must pass over waypoint 5.

Mission Description

In this mission, you will for once have a real advantage in terms of the means needed to accomplish the job. In order to get the bombers safely to their targets and back, you have to eliminate the northern enemy CAP flights and the air defences deployed around the airfields which the bombers will attack.

By constituting fighter wolfpacks again, you should have no trouble at all eliminating the enemy fighters, and even if your first wave does not get all of them, the second wave, which will begin to show up about 10 minutes into the mission, will surely finish them off.

To handle the enemy air defences, you will get 7 Wild Weasel flights. AMBER1and 2 are designated to clear the path for RAID1, and AMBER3-7 are tasked to clear the way for RAID2-4. Your job is pretty much to ensure they really complete their task. As with all AI-piloted flights, they tend to revert back to cruise mode after one pass, even if their targets are not completely destroyed, in which case you have to order them to strike again and again until all enemy air defence units are destroyed.

With all the threats gone, the bombers will just have to complete their milk runs and overfly their refuel waypoints before the success box will appear.

Mission 5

Deliver the Message

Mission Type

AWACS

Mission Objectives

JSF flight STRIKER1 must fly over waypoint 7

JSF flight STRIKER2 must fly over waypoint 8

F-18E flight COMBAT3 must fly over waypoint 7

F-18E flight COMBAT5 must fly over waypoint 6

Mission Description

As a sting in the tail the final seems to have been planned on a shoestring budget, you will barely have enough forces to get the job done.

As usual in the case of bombing missions being conducted into enemy territory, you have to make sure nothing gets in their way. As in the previous mission, deploy your fighters in wolfpacks against the enemy CAPs, and make sure you also use all AWACS, JSTARS and refueller escorts, you will need them. Special care should be given to the enemy AWACS plane, if you destroy it swiftly, some distant enemy fighters may not even join the battle. However, do not relax once you have destroyed the AWACS, a replacement will join the battle after about 15-20 minutes, and the sooner you kill it, the better. The second AWACS will take off from Lawdar, so might want to task a CAP near the airfield to get the AWACS as soon as it takes off.

As independent SEAD flights, you will get two F-15E flights, with which you ought to destroy all air defence units along the routes of the strike packages. Although the strike packages will be accompanied by Wild Weasel escort flights, you cannot really afford to lose a single plane of the strike packages or its escorts to ground defences. Usually, some enemy fighters will get through to the strike packages, and if their numbers are already diminished by losses to SAMs/AAA, the attacks by the fighters might just be enough to eliminate a strike flight completely – in which case you will lose the mission.

However, the single fighters you should expect as leakers ordinarily do not have enough armament left to eliminate an unblooded strike package plus escorts, and even if you suffer some losses, one or two planes of the strike flights usually make it back to their post-strike checkpoints. Once all strike flights, or what is left of them, have passed their post strike checkpoint, the success box will pop up.

Part IV The Saudi-Yemen Tour

Every rational person would assume that Yemen, after losing a full blown campaign and getting its nose blooded again in a minor skirmish, would finally have got the message that the U.S. is definitely determined to preserve the territorial integrity of its staunchest middle east ally. But, with both Russia and China backing its actions and providing the military means to accomplish them in the first place, Yemen is still bent on 'liberating' the disputed oilfields near the border.

However, U.S. and Saudi reconnaissance assets have uncovered the plans for the latest military attempt to settle the score and the governments of both countries have decided to launch a pre-emptive campaign to thwart the attack. In this tour, you will therefore operate in a full blown war – no more pussyfooting around in so called limited or retaliatory strikes.

Mission 1

Counter – Recce

Mission Type

Air Intercept

Mission Objectives

You must destroy MiG-27R flight AL_ARBIA 2 before it passes over (its) waypoint 4.

You must destroy Tu-300 flight AL_ARBIA 3 before it passes over (its) waypoint 2.

You must destroy MiG-27R flight AL_ARBIA 4 before it passes over (its) waypoint 4.

You must destroy MiG-27R flight AL_ARBIA 5 before it passes over (its) waypoint 4.

You must land at Ash Shararwrah

Mission Description

The main problems in this mission are that you have enemy recce planes converging on you from all directions and that you have no idea

how their respective flight plans look like and when they will pass their target waypoints. To be on the safe side, you therefore ought to eliminate all recce planes as fast as possible.

When the mission starts you will find yourself sitting on the runway, and the clearance to take off has already been granted. Since speed is of the essence, open the throttle and take off immediately.

Leave the throttle fully open and turn east, the Tu-300 should be about 100 miles away. Close to within AIM-120R range and hand off this target to your wingman, because a MiG-27R should get airborne just as the Tu-300 comes into range. This MiG-27R is one of your other targets and if you handle the Tu-300 yourself, it might get away. Thus, turn North and engage the MiG.

After you have dispatched the MiG-27R (your wingman should just about be done with the Tu-300 by now), turn to a heading of 270 degrees and open the throttle fully again. Another MiG-27R, escorted by 4 MiG29Ms about 100 miles away should just turn east towards its target waypoint. Close as fast as possible and take it out, but try to avoid to become engaged by the MiG-29Ms, you still have one more target to take out.

At this point, two MiG-27Rs still remain on the board, but in terms of mission accomplishment, the closer one is a decoy. Thus, head for the one further out (but avoid those 29s) and dispatch it. Hopefully, you will still have enough fuel on board to make it back to base after all this throttle-open, afterburner intensive flying.

Mission 2

First Moves

Mission Type

SEAD

Mission Objectives

You must kill 4 SA-11 groups and one ZSU23/4 group (all enemy ADF units in your designated killbox).

F15E flight SHAR1 must fly over waypoint 4.

You must land.

Mission Description

To clear the way for the first waves of strike flights, all allied stealth planes are tasked to destroy enemy air defence assets. In your case, this means you have to take out five enemy ADF groups in the area designated as the killbox for your flight.

In the mission, nothing of interest will happen until you close on waypoint 4 and cross the border into enemy territory. On route to waypoint 4, you might have to take a slight detour to the West from

the flightplan to avoid entering the engagement range of a SAM site, but this is more a nuisance than a threat. Once you have passed waypoint 4 things will become interesting. A lot of enemy radars will come up, which is both good and bad. Good because in order for your weapons computer to build a shootlist, the enemy radars must paint you. Bad because the enemy SAMs and AAA can obviously fire on you when they see you on radar. Another aspect which makes this mission more difficult is the fact that the ADF units are deployed in hilly terrain, which occasionally causes them to disappear from your threat display until you are almost on top of them and they open fire immediately. And if this was not already enough, you only have about 10 minutes to kill all the SAM sites before the F-15Es will enter the killbox. All thrown together, a mission with a high pucker factor – but still doable.

After you have passed waypoint 4 and are inbound to waypoint 5, the first enemy radars will come up in the killbox. The first you ought to see is in the Southernmost corner of the killbox. As soon as this one comes up, hand it off to your wingmen.

Due to the hills, terrain masking can become a real problem, but the flightplan has been plotted with regard to this problem. You should therefore continue to follow it on an Easterly heading and handing off the ADF units mentioned above will enable you to do so, engaging the SAM sites as they come up. You will probably find that you have to fly slight s-turns to keep the enemy radars alive on your threat display, banking the F-22 increases its Radar Cross Section (RCS). On the other hand, returning to level flight might just decrease the radar section enough to creep out of the engagement range of a SAM site without drawing fire.

If you keep more or less to the Easterly heading, all enemy SAM sites will come up eventually, enabling you to take them out.

Once you have completed this task you should wait for the F-15 flight to pass through the kill box (and you might have to take out a flight of enemy interceptors during your wait) before you head home. Speaking of which, in this mission, you do not have to fly all the way back to your takeoff base, landing at any allied airbase will be enough to accomplish the mission.

Mission 3

Embassy Evacuation

Mission Type

Escort

Mission Objectives

Stallion flight JOLLEY1 must fly over (its) waypoint 8

(your waypoint 5).

You must land at Jazan.

Mission Description

This missions calls for you to escort 3 groups of helicopters deep into enemy territory, 2 flights of Apaches and a flight of Super Stallion transport helicopters. You will be spelled by another group of F-22s once they have reached the target area, but on the inbound leg, they are your responsibility. Since choppers definitely fly a lot slower than a F-22, they are already en route when you enter the cockpit, so get into the air quickly and rendezvous with them.

Due to the fact that you will venture deep into enemy airspace, you should fly this mission more from a commanding than an acting perspective, you will only succeed if you husband your resources and use your wingmen wisely.

The first threat you have to take out are the air defence units on the enemy coast between waypoint 2 and 3. Do not engage them yourself, hand them off to your wingmen, you will need your A2G ordnance later on.

For the first 20-25 minutes, your progress should go unnoticed by the enemy CAP flights, but unfortunately, after that time has elapsed, an enemy AWACS will come up and start to vector the fighters towards your group. At this point, you have to deploy your wingmen to counter those threats. However, keep them under close observation lest they go off after targets of opportunity like a couple of Mi-40s cruising through the area – hardly a threat to your mission and thus not worth wasting a missile on.

As more and more fighters close in, you will reach a point were you have to take an active part yourself. Still, try to be as economical as possible with your wingmen and do not engage flights which do not pose a threat to you, for example the enemy strike flight of Su-34s taking off.

Sooner or later, all enemy CAPs should be dispatched and you are probably without wingmen at this point. Proceed towards the target area and destroy the enemy ADF units deployed there. You will notice the enemy AWACS with its escort closing on your position, but if you do not engage them, they will turn back.

Once you have killed the air defences, stay at the target area until the helicopters arrive. A couple of enemy interceptors might take off from the airbase, and the sooner after takeoff you kill them, the better.

While you are circling the target area, another flight of F-22s will arrive to take over, and you should also witness an allied strike levelling the better part of the airbase near the target area. Wait until the choppers have overflown their waypoint 8, then had home.

Mission 4

Special Forces Rescue

Mission Type

Close Air Support (CAS)

Mission Objectives

HUMVEE group must have survived.

You must kill 2 BMP3 groups.

You must land at Ash Shararwrah.

Mission Description

This is again a scramble mission, so take off as soon as you enter the cockpit and get towards the target area at full throttle. The briefing for this mission is a bit coy about which forces are really threatening your special forces insofar as it only explicitly states that you have to kill the enemy ground forces opposing the special forces. However, there are also a couple of enemy strike flights intent on killing your troops, and the necessity for their destruction is implicitly stated in the survival condition.

As you get close to the killbox, you should note a flight of two Mi-24s just entering the killbox, this is the first flight you have to remove. Next you should dispatch the enemy ground forces. There are two groups approaching the special forces position, hand off one to your wingmen and take out the other group yourself.

After you have taken care of the ground forces a flight of 4 Su-25s should just about enter AIM-120C range from the north, and you have to take them out as well. At this point the enemy CAPs will probably finally have become aware of your presence, and depending on the enemy CAP activity around you might have to take a break from killing your assigned threats to fight off the interceptors interfering with your work.

There is still another flight of Su-25s closing in on the special forces, and you have to kill them as well before you can bug out.

Mission 5

Fighter Sweep

Mission Type

Fighter Sweep

Mission Objectives

You must kill Su-37 flights GHAALI 1, 2 and 3.

You must kill MiG-29M flights KHALAZ 1, 2 and 6.

You must kill A-50 flight SHAZAM1.

You must land

Mission Description

In this mission you will have to fight your way past the enemy CAPs to destroy one of his most valuable assets – one of the rare A-50 AWACS planes. However, as the enemy has been loath to deploy them, you will have to go in and destroy it on the ground.

You will start this mission from one of the recently captured enemy bases and, as in the previous mission, you are already on the runway when the mission starts. Take off and follow your flightplan until you have reached waypoint 2. You will notice three flights of Su-37s deployed more or less along a line perpendicular to your flight plan. If you had followed your flight plan, you would head straight into a fight with 10 Su-37s, not exactly a healthy situation.

Instead of doing that, continue past waypoint 2 in a roughly South-Easterly/Southerly direction. The plan is to hook around to the South and to roll up the line of interceptors from there, and rather than taking them on simultaneously, we can pick off the flights one by one.

Once you are sure you will only be met by one CAP when you turn in, head towards the bandits. Order your wingmen to engage and follow them in. Stay outside the main fight and pick out the targets your wingmen have missed. Sooner or later, the three Su-37 CAPs will succumb to the onslaught.

Next are the two MiG-29M CAPs between you and your ground targets. Compared to the 10 Su-37s, a mere 4 MiGs should not present much of a problem.

After the MiGs are out of the way, proceed towards your ground targets. The AWACS plane and its escort flight, which you also have to take out are at the more Westerly of the two airbases in your killbox. However, the two airfields and the two neighbouring cities are well defended, and if you have begun to wonder why you were lugging all those Mavericks around, that is why.

With the help of your wingmen, clear a path through the enemy defences until you have a clear shot at the planes on the ground. Once they are destroyed, there is no reason to linger, head back home.

On the way out, you might have to fight your way past an additional CAP flight or two, so it is wise to retain some A2A ordnance.

Mission 6

Downtown SEAD

Mission Type

AWACS

Mission Objectives

F117A flight GHOST1 must fly over waypoint 7.

F117A flight GHOST2 must fly over waypoint 9.

F117A flight GHOST3 must fly over waypoint 8.

JSF flight STRIKER1 must fly over waypoint 8.

JSF flight STRIKER2 must fly over waypoint 9.

Mission Description

This mission is, in a way, a replay of the second mission, albeit on a much larger scale. As AWACS commander, you have to ensure that the 5 strike flights GHOST1-3 and STRIKER1-2 make it to their respective targets and back towards their assigned post-strike refuellings.

In order to ensure the safe passage of the strike flights, the airspace has to be cleared of enemy fighters and the air defence units deployed around the target areas have to be eliminated. Although this mission is coined as an AWACS mission, you better be prepared to jump into an F-22 cockpit quite often, this mission is hardly winnable without doing so. Luckily, there are plenty of F-22s around.

First order of business is to take out the enemy fighters. Therefore, get every A2A tasked allied fighter to head into enemy airspace to get this done. Make sure to take part in the ensuing intercepts as often as possible, the chances of a successful intercept will be much better with you leading it. However, only jump into the cockpits when the fight is imminent and not to transit from one fight to the next, it is vital that you keep abreast of developments elsewhere.

Once the enemy fighters have been taken out of the picture, it is time to concentrate on tackling the air defences. Move the mouse over each of the strike flights to call up its flightplan. Note the target areas and the air defences they have to fly through on their way in. Now look around for CAS tasked flights. You ought to find a couple of F-18Es tasked with close air support as well as numerous F-22 flights. Use the F-18Es to clear out the threats near the borders and use the F-22 flights to take out the air defences in enemy territory. As with the intercepts, jump into the F-22 cockpits as soon as they are approaching the target areas, they will be much more efficient when closely lead.

Now and then, an enemy replacement CAP will take off and try to influence the outcome, so make sure you watch out for those.

Speaking of enemy planes taking off, the strike flight GHOST2 is liable to blunder right into the path of an untimely launched flight of Su-35s, so you better attach an escort to this particular strike flight.

Apart from that, the mission is a lot of work, but ultimately, winnable. Once you have taken out all threats and the strike flights have taken out their targets, you can time-accelerate until all have reached their refuelling waypoints, at which point the mission will end.

Mission 7

Beachhead Preparation

Mission Type

AWACS

Mission Objectives

You must have killed 7 T-80 groups.

You must have killed 6 SA-11 groups.

You must have killed 3 ZSU23/4 groups.

Mission Description

In this mission, it is your responsibility to clear the landing beaches around Aden of all enemy ground forces, which is quite a tall order, as the number of mobiles you have to destroy amounts to 116. However, all the means to complete the task will show up sooner or later, and it is just a matter of using them correctly.

As in the previous mission, your first task is to establish air superiority over Yemen. The good news is that Yemen is slowly running out of Class-1 fighters, once you have eliminated the CAPs already airborne, only a few more will be scrambled, and most of the replacement CAPs will consist of MiG-21 pairs. The bad news however is that there are lots of enemy CAPs already up, and they are mostly made up of Su-37s and MiG-29Ms.

To counter that threat, you have numerous allied CAP flights at your disposal, and quite a few of those are F-22 flights. As in the previous mission, it is paramount you handle most if not all the F-22 intercepts. In a computer-controlled fight between Su-37s and anything else, anything else usually loses the fight. On the other hand, if you lead the F-22s, there is a good chance you can get them in and out without losses.

Apart from the air superiority concern, you also have to handle the ground force disposal. Numerous allied strike flights will be launched towards the landing sites, the most important of those being three Saudi-Arabian F-22 flights (MUMTAZ4-6) and four U.S. A-10 flights (BEAST1-4). These flights represent all the striking power you will need to take out the ground forces.

In executing the ground attack, your first task is to eliminate the air defences, and you best use the F-22s to accomplish that. As in the dogfights, the ground attacks will be more efficient if you lead them from the cockpit. Once you have eliminated the air defences, you can focus your attention on the enemy tank columns.

If there are still F-22s armed with Mavericks left, you can use them to begin to reduce the number of enemy tanks. However, the planes really suited for this task are the A-10, because they are the only AI-piloted planes which will use their cannon to strafe ground targets.

Once they have arrived over the target area, your task is to constantly assign them new targets. As all AI-controlled planes, they tend to make one pass and then revert back to cruising mode. With most AI-controlled planes, this actually makes sense since they tend to use all their armament in that one pass. The A-10 however, being equipped with a 30mm cannon, has a lot of passes in it, and you have to ensure they are being used. Whenever an A-10 flight wants to leave, order them to attack the tanks again, they will comply until they have run out of rounds for the cannon, which will take quite some time.

As outlined above, if you keep a close eye on the air to ground battle, destroying even the seemingly impossible large number of ground targets is possible and as soon as the last tank is gone, the box announcing mission success will appear.

Mission 8

Beachhead Isolation

Mission Type

Interdiction

Mission Objectives

You must destroy 3 bridges.

You must land at Ash Shararwrah.

Mission Description

Although the landings around Aden, have been successful, only a fraction of the troops aboard the ships have been deployed so far, and the beachheads could still be smashed by a determined enemy counterattack. Thus, destroying the routes leading towards the landing sites will be a major step towards denying the enemy this opportunity. In this context, your task is to destroy three bridges over which the enemy could route heavy armour.

As far as combat missions go, this one is a breather compared to the previous missions – the enemy has been badly mauled during the previous sorties and it shows. You will encounter no opposition until you have almost reached your first target. As you approach the first

target, you will have to deviate a little from the flight plan to circumvent an enemy SAM site. Around the targets themselves are only ZSU23/4s deployed – no threat if you stay high enough, above 6,500 feet.

Close to the first target, you might have to dispatch a flight of two MiG-27s, but that's about it as far as enemy air opposition is concerned, once they are gone, you can destroy the three bridges at your leisure.

On your egress, a couple of enemy CAP flights are deployed close to your route. Since the enemy has no AWACS deployed, you have the option of either engaging them or to plain fly around them.

Mission 9

Fleet Defence

Mission Type

AWACS

Mission Objectives

KUZNETSOV must be destroyed.

NIMITZ must NOT be destroyed.

KC-135 flight TEXACO1 must fly over waypoint 3.

Mission Description

After being hit by the Russian submarine, the carrier Nimitz is unable to conduct flight operations and is therefore almost defenceless against air attacks. In addition, the allied HQ is determined to take revenge for this sneak attack, and the carrier KUZNETSOV seems to be the proper target to deliver the message to.

As in the previous AWACS missions, I will assume you will get into the cockpits of the various F-22 flights when they enter their respective fights.

Your first task in this mission is thus to redeploy your CAP flights to cover the carrier. However, in contrast to the previous AWACS missions, no enemy AWACS is up. Apart from the enemy flights with a predetermined target, the enemy CAPs will thus only attack planes which enter their sensor range instead of being vectored towards the allied flights by the AWACS. For you, this means that you can pick your battles. Instead of having to destroy each and every CAP over Yemen, you can ignore those deployed in the north and west and immediately redirect the allied CAPs towards other tasks without having to fight their way in.

The enemy will launch three attack waves against the NIMITZ, all of which will be marked as 'HIGH THREAT' and will thus be easy to

recognise. Although it is theoretically possible to fight them off with the three F-22 CAPs already deployed around the carrier, another flight or two of F-22s won't hurt.

However, you should not strip the AWACS of its escort in this mission, the enemy will launch two Anti-AWACS flights and although the mission objectives do not explicitly state that the AWACS must survive, you will definitely lose the mission if it gets shot down.

To take out the Russian carrier, you will only get one flight armed with Harpoons, MUMTAZ1, which obviously has to get through. Unfortunately, the carrier is defended by four Su-37 CAPs, and whilst there is a chance you can fight your way past the CAPs with MUMTAZ1, it gets a lot easier if you redirect one or two F-22 CAPs to handle the Su-37s before the strikers arrive.

Once you have killed the carrier and fought off the enemy attacks on the NIMITZ, you only have to wait for the tanker TEXACO1 to leave its patrolling orbit which should happen at about 610 mission time. Once it has passed waypoint 3, the success box will come up.

Mission 10

Goodbye!

Mission Type

AWACS

Mission Objectives

3 command bunkers must be destroyed.

You must NOT run out of time.

Mission Description

Although the enemy has taken a terrible beating, it seems they are still not prepared to quit. However, if you win this mission, all the hard-liners will be dead and Yemen will finally sue for peace.

Airwise, the situation is pretty quiet, the enemy has not many fighters left and therefore, you can easily pick off the few airborne CAPs at your leisure.

The mission revolves around three pairs of flights destined to destroy the bunkers:

- IRON2 (striker)
- MUMTAZ2 + WAHID3 (SEAD flights)
- IRON3 (striker)
- MUMTAZ1 (SEAD flight)
- IRON4 (striker)

• MUMTAZ3 + WAHID5+6 (SEAD flights)

Your task as AWACS commander is to ensure that the SEAD flights get to their respective areas and that they remove the deployed enemy air defences before the strike flights arrive. You may take an active part in this again, since all F-22s, even those designated as escorts for the Tornados carry Mavericks.

After the air defences have been removed, the strike flights should have no problems getting in and destroying the bunkers. In case you want to execute the final attacks of the campaign yourself, please note that you have to drop both JDAMs on the command bunkers to destroy them, one will not do the trick.

You have exactly one hour to accomplish this, after this time, you have either failed or the success box will come up.

• MUMTAZZ + WATERS = SEAD flights

Your task as AWACS commander is to ensure that the SEAD flights get to their respective areas and that they remove the Republic's enemy air defenses before the strike flights arrive. You may take an active part in this again, since all F-22s, even those designated as escorts for the Tomahawk-carry Strikeeagles.

After the air defenses have been removed, the strike flights should have no problems getting in and destroying the bunkers. In case you want to execute the final attacks of the campaign yourself, please note that you have to drop both JDAMs on the command bunkers to destroy them. One will not do the trick.

You have exactly one hour to accomplish this. After that time, you have either failed or the success box will come up.

Chapter 10

THE ENEMY

AIRCRAFT & WEAPONS

TACTICS & PERFORMANCE

EM DIAGRAMS

CHAPTER 10

Chapter 10

The Enemy

After progressing through the simulator missions, Tours of Duty and the advanced techniques in A2G and A2A Combat, (coupled with the performance chapter), you will now have a firm grasp on the capabilities of the F-22. This Chapter will provide you with declassified information on enemy aircraft, missiles, SAMs, AAA along with an explanation of some of the simulation's mechanics that you can use to your advantage.

Part I Aircraft & Weapons

The following tables contain essential information regarding the critical performance as well as typical A2A mission armament for the primary air threats in F-22 ADF/TAW.

Su-37

In a dogfight the Su-37 is not much of a handful for the F-22, however it is the greatest threat in F-22 ADF/TAW as it carries the R-77R.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1127	1125	1115
	Corner	Sustained	Stall
	398	371	133

Armament

Short range A2A	6 R-77s
	4 R-77Rs
Long range A2A	4 R-77s
	2 R-77Rs

Su-35

Like the Su-37, the Su-35 is easily dealt with in a dogfight, but again it carries the deadly R-77R.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1210,	1209	1199
	Corner	Sustained	Stall
	389	360	130

Armament

Short range A2A	2 R-73s
	4 R-77s
	2 R-77Rs
	2 R-27ERs
Long range A2A	2 R-73s
	2 R-77s
	2 R-27ETs

Like the Su-37, the Su-35 is easily dealt with in a dogfight, but again it carries the deadly R-77R.

Su-30

Although the Su-30 is primarily a strike aircraft its performance is still superior to most allied aircraft.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1196	1194	1184
	Corner	Sustained	Stall
	389	361	130

Armament

Short range A2A	2 R-73s
	6 R-77s
	2 R-27ERs
Long range A2A	2 R-73s
	2 R-77s

Su-27

The Su-27 is is still one of the better dogfight aircraft in F-22 ADF/TAW. Its sustained turn rate puts it on a par with the MiG-29 and you should not underestimate it in combat.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1196	1194	1184
	Corner	Sustained	Stall
	382	342	127

Armament

Short range A2A	4 R-73s
	2 R-27ETs
	4 R-27ERs
	4 R-73s
Long range A2A	2 R-27ETs

MiG-21

The MiG-21 is obsolete in F-22 ADF/TAW despite various upgrades. The small number of weapons it carries puts it at a further disadvantage.

	Sea Level	20,000 feet	40,000 feet
Top Speed	908	903	878
	Corner	Sustained	Stall
	334	253	126

Armament

Short range A2A	2 R-73s
	2 R-77s
Long range A2A	2 R-77s

MiG-27

The MiG-27 is primarily a strike aircraft, although you will find it appearing in the CAP role when the lesser powers are short of front line interceptors.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1069	1062	1021
	Corner	Sustained	Stall
	416	293	157

Armament

A2A 2	R-73s
	2 R-27ETs

MiG-29

The MiG-29 has been covered in depth in Chapter 4, 'Performance' and as we know it is an energy fighter, therefore the MiG-29 tends to dogfight at high speeds.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1148	1146	1136
	Corner	Sustained	Stall
	381	341	127

Armament

Short range A2A	2 R-73s
	2 R-77s
	2 R-27ETs
	2 R-27ERs
Long range A2A	2 R-73s
	2 R-27ETs
	2 R-27ERs

MiG-31

As a long range interceptor the MiG-31 has poor dogfighting performance, its real asset being its high speed.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1421	1418	1401
	Corner	Sustained	Stall
	450	362	154

Armament

Short range A2A	4 R-27ERs
Long range A2A	2 R-27ERs

MiG-35

The MiG-35 is an enhanced MiG-29 that has a slightly slower performance envelope.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1129	1126	1108
	Corner	Sustained	Stall
	426	328	142

Armament

Short range A2A	4 R-77s
	2 R-27ETs

	2 R-27ERs
Long range A2A	4 R-77s
	2 R-27ERs

Mirage

A low sustained turn speed can provide a careless or unwary F-22 pilot with a shock, however, the Mirage is really a low threat.

	Sea Level	20,000 feet	40,000 feet
Top Speed	974	970	946
	Corner	Sustained	Stall
	341	210	114

Armament

Short range A2A	2 AIM-9Xs
	2 AIM-120Cs
Long Range A2A	2 AIM-120Cs

Rafale

The Rafale's greatest asset is its vast armament. In scenarios where you face Rafales in the air superiority role expect large volleys of the very missiles you employ.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1012	1009	990
	Corner	Sustained	Stall
	388	284	129

Armament

Short range A2A	4 AIM-9Xs
	4 AIM-120Rs
	4 AIM-120Cs
Long range A2A	4 AIM-9Xs
	2 AIM-120Rs
	4 AIM-120Cs

F-16U

The F-16 and F-16U share the same flight model and neither should prove much of a challenge for the F-22 pilot.

	Sea Level	20,000 feet	40,000 feet
Top Speed	1090	1087	1068
	Corner	Sustained	Stall
	440	351	147

Armament

Short range A2A	2 AIM-9Xs
	6 AIM-120Cs
Long range A2A	2 AIM-9Xs
	4 AIM-120Cs

Hard and Soft Targets

In common with EF2000, F-22 ADF/TAW uses a combination of structural strength points and target classification, modified by the missiles potency, for calculating the damage inflicted by A2A missiles. The differences are easy to recognise and can be exploited to ensure you make maximum use of your ordnance.

Hard Targets

This classification applies to almost everything that could not be considered a fighter or helicopter, for example, AWACS, transports and refuellers. Enemy hard targets can take up to two AIM-9X hits to down and will need at least 10 direct 20mm hits, roughly twice as many as a fighter. A single AIM-120 hit is more often than not enough to down a hard target.

Soft Targets

All fighters and helicopters fall into the soft target category. Direct hits by single AIM-9Xs are enough to deal with these targets the majority of the time. AIM-120s have an almost 100 percent record against such targets. Soft targets can usually be downed by five direct 20mm hits from your gun.

Enemy Air to Air Weapons

In F-22 ADF/TAW missile performance has been calculated on the anticipated performance of the next generation of technology. As a result certain weapons have almost become 1 shot 1 kill or 'magic bullets'. The important point is 'almost', there are ways to reduce the PK of enemy missiles see part II of Chapter 4, 'Performance'.

Missile range comparison.

Archer

Missile	Rmin (nm)	Rmax (nm)	Max G	SL	Top speed (Mach) 20,000 feet	40,000 feet
R-73	0.5	5.9	24	2.5	2.7	3.0

The all aspect R-73 Archer is the most potent short range IR missile in F-22 ADF/TAW. While comparable to the AIM-9X against most fighter class (soft targets), the R-73 does significantly more damage to larger aircraft, such as C130s, AWACS and JSTARS. Although the R-73 has a slightly shorter range than the AIM-9X this is offset by its great lethality.

R-77 'AMRAAMski'

Missile	Rmin (nm)	Rmax (nm)	Max G	SL	Top speed (Mach) 20,000 feet	40,000 feet
R-77	2.7	17.6	22	3.3	3.6	3.9

The most commonly employed enemy missile in F-22 ADF/TAW the R-77 is slightly inferior to the AIM-120C.

R-27ET/ER Alamo

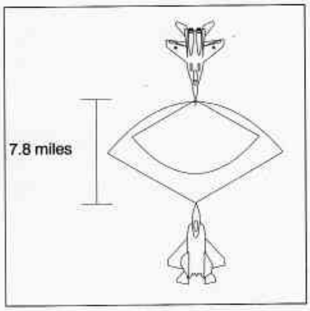
Missile	Rmin (nm)	Rmax (nm)	Max G	SL	Top speed (Mach) 20,000 feet	40,000 feet
R-27ET	4.3	27.7	20	3.8	4.1	4.5
R-27ER	4.3	29.7	20	3.9	4.3	4.8

The R-27 variants are almost identical in performance, the designation differentiates the ET as Infra red homing and the ER as radar guided. These missiles are on a par with the AIM-120.

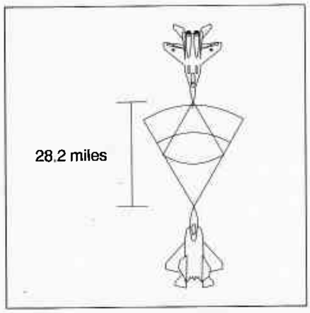
R-77R

Missile	Rmin (nm)	Rmax (nm)	Max G	SL	Top speed (Mach) 20,000 feet	40,000 feet
R-77R	8.1	46.7	20	5.1	5.6	6.3

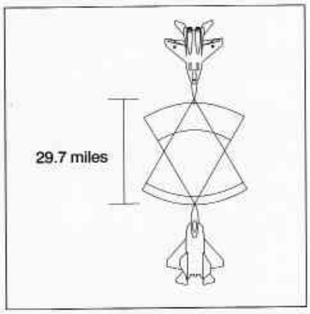
The R-77R's extremely high speed and 40 percent greater range over the AIM-120R make it the most effective missile in F-22 ADF/TAW. Fortunately it is only carried by the Su-35 and Su-37.



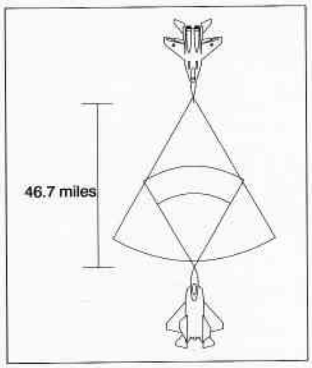
AIM - 9X vs R73



AIM - 120C/R vs R77



AIM - 120C/R vs R27ET/ER



AIM - 120C/R vs R77R

Difficulty Settings.

Missiles

As we explained in the Missile section of Chapter 4, 'Performance', it is very difficult to manoeuvre spoof a missile and hence you must rely on countermeasures and degrading a missile's manoeuvrability by taking it to low altitude. However, the difficulty level you set in the options screen effects the performance of your countermeasures. At the hard setting each countermeasure has a 5-6 percent chance of attracting a missile. This rises to 10-12 percent at medium and to 45-50 percent at the easy setting. When tackling radar guided missiles your Radar Cross Section (RCS) helps modify these values in a positive or negative way (at harder difficulty levels your RCS is harder to control). For infra red guided missiles your aspect has a similar effect.

Aircraft

Enemy aircraft performance is also effected by the difficulty level. At the Hard setting the AI will use the full performance envelope of its flight model, whereas at the lower settings it will be restricted to less strenuous manoeuvres, below 7 G.

Damage

The enemy aircraft are able to sustain varying levels of damage, although individual systems are not modelled on each aircraft it is possible for the damage you inflict to have a significant effect on their flight performance. As a general rule, any aircraft that is trailing smoke will lose up to 35 percent of the potential G load it can sustain.

Part II

Tactics & Performance

Enemy Air to Air tactics

Since every aircraft in F-22 ADF/TAW has a six degree of freedom (6 DOF) flight model you will notice that the computer controlled aircraft now behave more realistically in engagements than ever before. The Artificial Intelligence (AI) now has to fly within more stringent and authentic flight model conditions, rather than a simplified set of equations. As you may have observed whilst practising in the Custom Combat simulator, against some aircraft, flying the 'G for brains' technique is no longer an easy solution to an engagement - 'banking and yanking' will see you pulling the ejection handle more often than not.

Although you now have specific information regarding the performance of the enemy aircraft encountered in F-22 ADF/TAW you also need to understand how the AI will fly and what it is capable of. In previous DID simulations the AI would simply 'fly to the numbers', which equated to getting to Corner Velocity (CV) as fast as possible, and doing everything it could to remain there. With the new, more sophisticated algorithms in F-22 ADF/TAW the computer pilots have become more skilful in their energy management (see Chapter 4, 'Performance'). They now know how and when to trade their altitude and speed, and therefore appear to emulate real world tactics far more realistically. In the past it was possible for a good human pilot to 'learn the numbers' and fool the AI with manoeuvres like the scissors. It was simply a matter of flying at a speed below the enemy's CV in order to force the CV fixated opponent into an overshoot. This was possible because the players flight model was of a significantly higher fidelity than the one used by the AI. It was generally more manoeuvrable and after a little in-sim combat experience the player could spot and exploit the differences.

In F-22 ADF/TAW the enhanced 6 DOF flight model for the computer controlled aircraft allows far more flexibility than simply forcing the AI to 'fly the numbers' with a 'tail chase' mentality. In TAW this can be clearly demonstrated by setting up a guns only engagement with the EF2000 in Custom Combat. The EF2000 will

not fly to its CV religiously, but will instead use its entire flight envelope - right down to riding the stall, when that becomes appropriate. You will be unable to force an overshoot in a scissors, for example, unless you have already stalled. Instead of solely relying on the differences in CV to win every engagement you need to have a more thorough understanding of Basic Fighter Manoeuvres (see Part IV Chapter 6, 'A2A Combat').

The AI pilots will still always attempt to get on your six and will avoid head on gun shots, the logic behind the lack of head on gunshots is that the AI wants to avoid a collision or collateral damage from your debris. This is something you can use to your advantage whenever entering an engagement. In their attempt to avoid a head on shot, the AI will permit you to create flight path separation during the merge, this simply begs for the use of the 'Lead Turn' as your opening manoeuvre, this is described in more detail later.

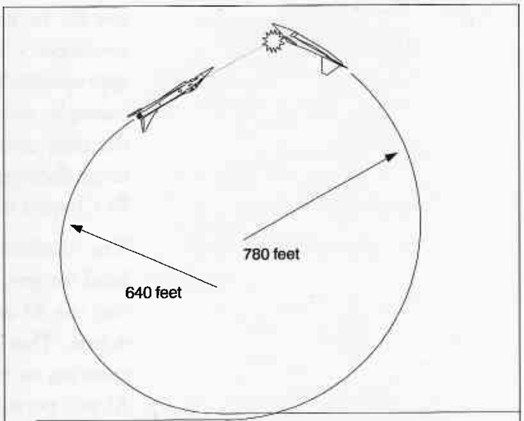
So we know the AI is always going to fly to our six, and that now it will utilise its entire flight envelope to achieve that objective. That is where the changes really show, the enhanced flight model results in greater flexibility and more intelligent use of areas in the envelope it was previously unable to explore, namely the stall fight. The AI will exploit advantages in its sustained turn rates and lower stall speeds where such an advantage exists, in some cases this means significantly smaller turn radii and the ability to turn inside your circle. A small turn radius will often give you the impression that you are being out turned, and can result in that sinking feeling you get when you see the offending enemy aircraft pulling its nose onto you almost as if it had just magically acquired thrust vectoring capability.

Aircraft Performance Comparison Table

Aircraft	Corner	Sustained	Stall
F-22 (players)	285	247	95
EF2000	289	193	96
JSF	313	266	104
Mirage	341	210	114
MiG-21	334	253	126
Su-25	324	262	127
MiG-29M	381	341	127
Su-27	382	342	127
Su-30	382	342	127
Rafale	388	284	129
Su-35	389	361	130
Su-37	398	371	133
Su-34	389	322	138
MiG-35	426	328	142
F-16	440	351	147
F-16U	440	351	147
MiG-31	450	362	154
MiG-27	416	293	157

By simply trying to remain at your best sustained turn rate you will find yourself losing position very rapidly against an enemy aircraft than can turn inside your circle. If you try to trade turns with your opponent under such circumstances, the AI will be spraying you with cannon shells before you can say 'Help me Sim-Tech!' (Figure 1). Not all of the enemy aircraft are able to exploit the low speed envelope equally well, see the Aircraft Performance Comparison table.

We will explain in detail a way of defeating the most formidable dogfight aircraft in TAW, once you can regularly defeat that aircraft you will be able to apply the techniques and concepts to all other enemy aircraft and emerge victorious from almost any dogfight.



In this diagram both aircraft have turned exactly the same angular distance in exactly the same time. However almost a 300 foot difference in the diameter of their turn circles results in a shot for the EF2000 in as little as 5 seconds if both aircraft are flying at their maximum sustained turn rates

Figure 1

EM Diagram for F-22 v EF2000

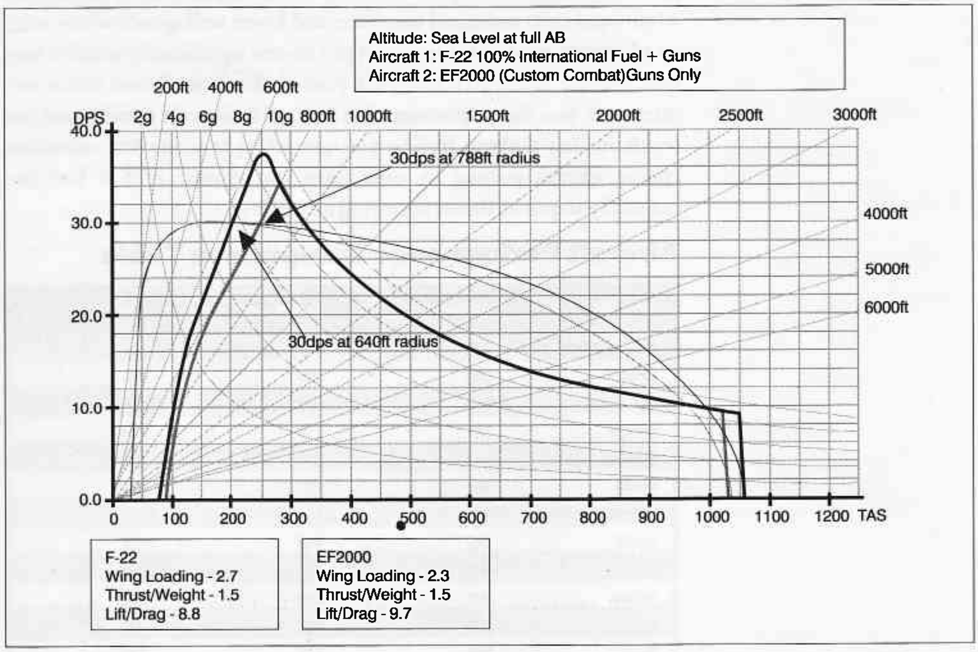


Figure 2

F-22 vs EF2000

Although you will never face an EF2000 in a TAW campaign, it is the most potent dogfight aircraft in the simulation. We will use an example of a hard difficulty setting, 'guns only', head on fight at low

altitude created in the Custom Combat generator. But firstly take a look at the EM diagram in Figure 2 for an overview of the relative aircraft performance as configured in the Custom Combat generator.

The important point to be deduced from this diagram is that below your corner speed, the EF2000 has a significant turn rate advantage, speed for speed. So for example when both aircraft are at 250 knots the EF2000 will out turn the F-22 at the rate of around seven degrees every second (7 dps). Also, the EF2000 has a significant turn radius advantage that is also illustrated in Figure 2.

Those factors can be decisive, and combine to give less experienced pilot's a very difficult time. All is not lost however because when both aircraft bleed energy down to their sustained values, their turn rates equalise at 30dps, as shown in the EM diagram. Therefore you clearly want to get to your best sustained turn speed as quickly as you can. At that speed, you have the same turn rate as the EF2000 and only need to deal with his smaller turn radius. If you and the EF2000 were able to maintain corner speed, the EF2000 would indeed have a 4dps advantage, as well as the smaller radius. Once you do bleed speed to your best-sustained turn rate, you will be able to match the turn rate of the EF2000 and by the use of good BFM, will be able to neutralise the turn radius advantage. We have been able to defeat the EF2000 in a one versus one engagement consistently by applying the following strategy.

As you enter the fight you will find the EF2000 some 5 miles away and up to 1500 feet higher than you. You will be flying at 650 knots. Your first move should be extend the airbrake and get your speed down to around 425 knots (do not forget to retract the airbrake). Once you have your speed under control the rest of fight happens in three distinct phases. In the first, the merge phase, you need to execute a lead turn in order to achieve an initial advantage. In the second phase, the EF2000 will use its higher instantaneous turn rate to neutralise the fight again. In the third and final phase, you will have the same turn rate as the EF2000, but will need to defeat its small turn radius. We will examine each phase in detail.

The Merge

As you continue to close with the EF2000 at full throttle while toggling the airbrake in order to maintain your speed, it will almost always go high. You should climb towards it, but stay far enough below it to maintain the flight path separation needed for the lead turn. You can do that by centring the enemy aircraft near the top of your HUD. As the range clicks down to 2nm you need to watch the position of the EF2000 relative to your HUD carefully. As the position of the EF2000 on the canopy begins to rapidly increase, it is

time for you to begin your lead turn. There is no hard fast rule for exactly when to execute the lead turn, it comes down to practice, after a few attempts you will come to recognise the 'right time' and it will soon become second nature (Figure 3).

It is very important to gain an advantage during this phase of the fight because the EF2000 driver will be able to win back most of what you have gained during his descent. Once you have executed the first phase of the engagement a few times you will be able to fine-tune your entry speed so as to stay above 230 knots in order to retain the ability to manoeuvre effectively. However, avoid allowing your speed to exceed 280 knots when the EF2000 begins the steep spiral turn towards the deck, or your turn radius will open up too far.

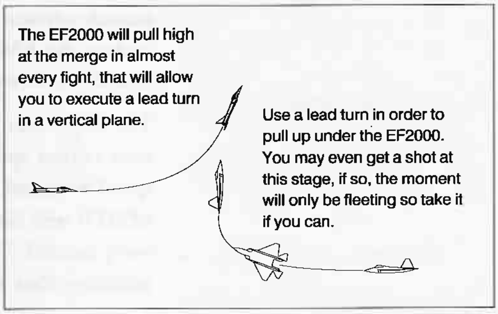


Figure 3

The Lufbery

If you execute your lead turn well, you will be saddled up nicely on the EF2000 as it rolls over into a Lufbery manoeuvre. During this manoeuvre the EF2000 will enter a very steep descending spiral turn which you must do your best to match. As both aircraft spiral downwards, the flight paths resemble a double helix, winding downwards as shown in Figure 4.

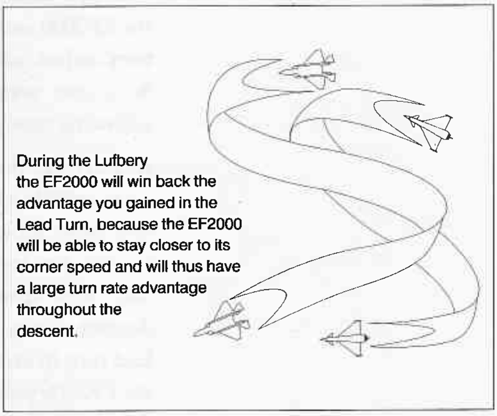


Figure 4

If you have managed to control your speed correctly during the lead turn and on the way down in the Lufbery you will find yourself a few hundred feet above the ground in a neutral position. However, the smaller turn radius of the EF2000 can, depending on the geometry of the resulting position, tip the balance against you. Any eccentricity in your respective turn circles will, due to the EF2000's smaller turn radius, work against you. Any attempt to reverse into a scissors will also be fatal for you because of the smaller EF2000's radius. Also, the smarter AI will now fly the scissors correctly and that manoeuvre is not recommended against aircraft that can take the fight as slow as you can.

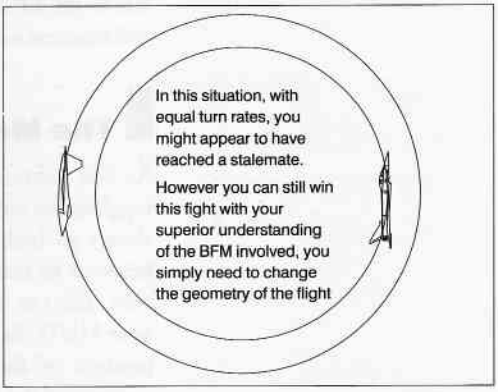


Figure 5

Now you are at the end of the second phase of the fight. If the EF2000 and you are turning in

concentric circles, you will be able to follow the EF2000 around almost indefinitely (Figure 5).

THE YO-YO

If you attempt to maintain a level turn, and use small yo-yos to gain angles, you will find that the EF2000 will match your manoeuvre so that you find yourself taking two steps forward, then two steps back. In this situation you need to manoeuvre out of the EF2000's plane of motion in order to create the opportunity to get a guns solution. The EF2000 will remain in a flat turn, but you need to perform a large yo-yo altering the geometry of the fight enough to give you a shot.

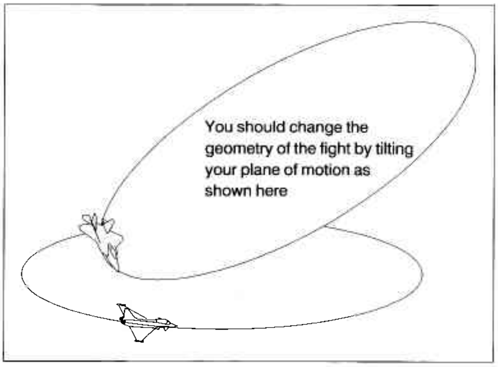


Figure 6

This large yo-yoing manoeuvre creates an offset in the turn circles that will eventually allow you to fire on the EF2000 on the downward leg of the yo-yo, one burst should be enough to finish the fight (Figure 6).

Conclusion

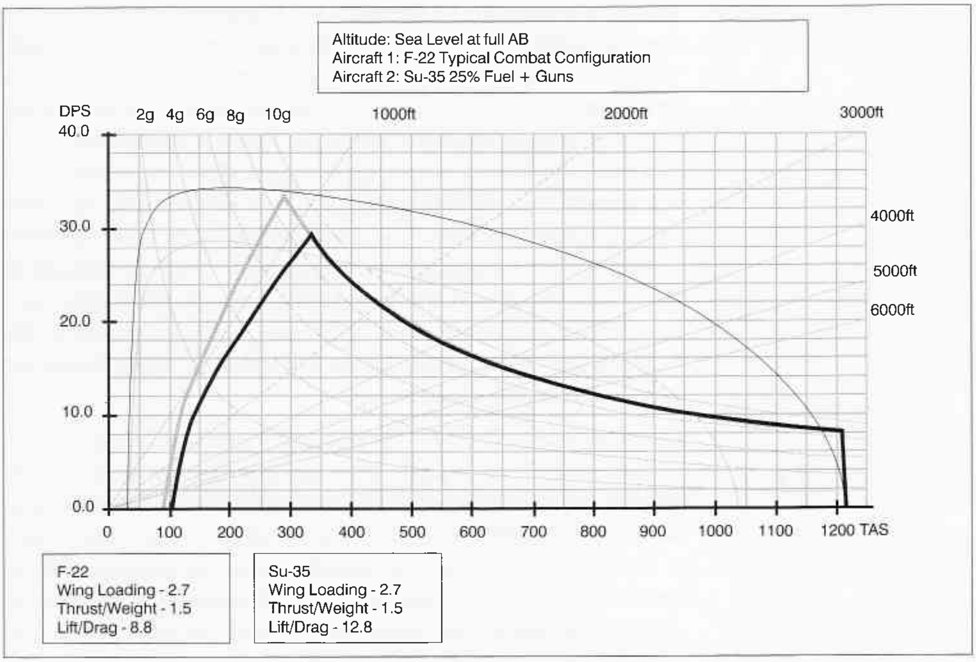
So we have illustrated one engagement where relying on Corner Velocity will not win you the fight. It is important to understand that the peak on the EM diagrams is the maximum instantaneous turn rate your aircraft can achieve, but as the name implies, you only get it for an instant, you cannot sustain it. During the Lufbery, the EF2000 has advantage because by trading altitude for speed, it can maintain closer to corner, and convert that energy to angles. However, as you saw in this example, you can reduce the fight to one where it is the sustained turning ability that counts. You must therefore compare the sustained turn rates of the F-22 against the main threats. Compared to nearly all the enemy aircraft you will have both a turn rate and smaller turn circle advantage. If you find the EF2000 too much of a handful, try the F-22 and JSF, EM diagrams for the JSF and main enemy threats are included at the end of this chapter.

One final word of caution. The effects of weight and drag apply to all aircraft in F-22 ADF/TAW, therefore your performance will be severely degraded should you wish to dogfight with iron under your wings. You should be wary of enemy aircraft returning to base who, it is likely, will be 'clean', and therefore their performance will be 'enhanced'. Use of the Custom Combat generator (in TAW) to set up engagements against the enemy aircraft with varying ordnance on your F-22 will help you hone your skills.

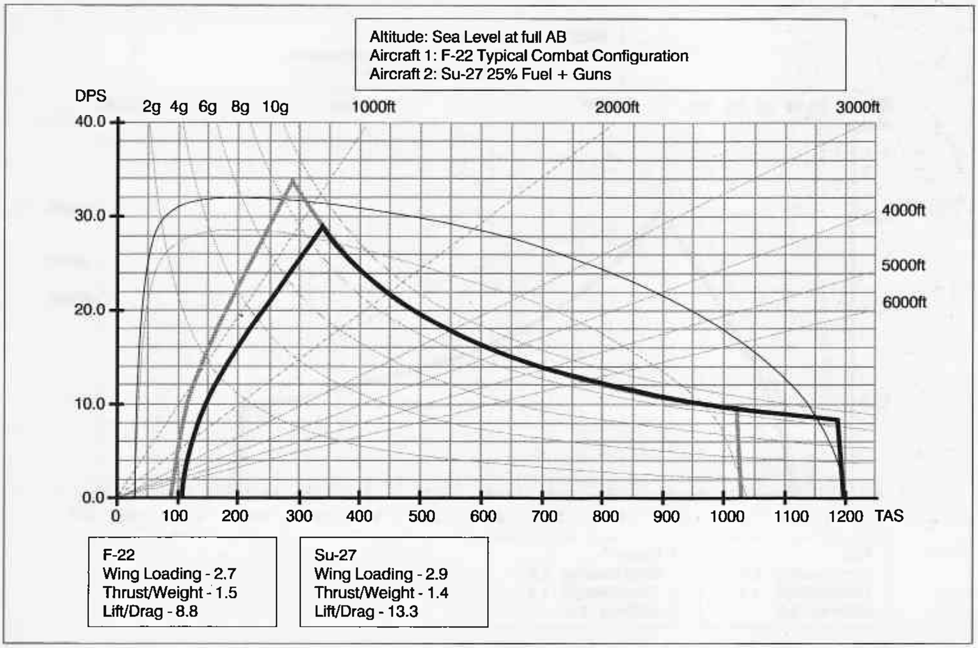
Part III EM Diagrams

The following EM diagrams cover the main threats and two strong allied dogfighters. We have chosen to illustrate a worst case scenario, with the F-22 carrying a typical A2A loadout and the enemy in almost optimum dogfight configuration. Once you can beat these aircraft while loaded, in the Custom Mission generator, you will worry less about encounters in the TAW campaigns that find you heavy with ordnance and fuel. Chapter 4, 'Performance', contains additional EM Diagrams for the F-22 and MiG-29 at various altitudes. As with those diagrams, the enemy aircraft are shown as the black lift and Ps curves.

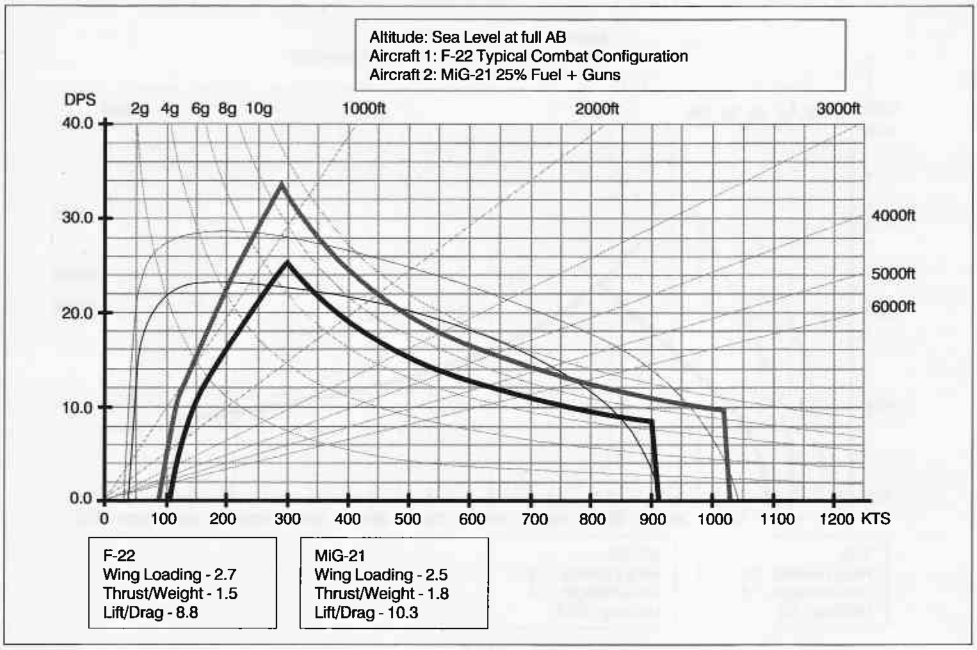
EM Diagram for F-22 v Su-35



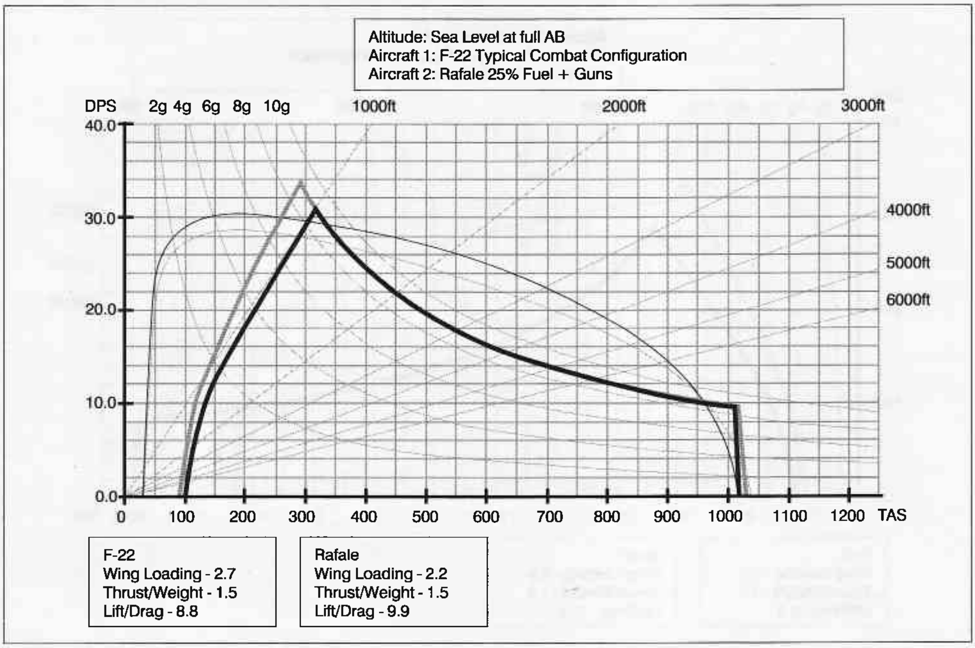
EM Diagram for F-22 v Su-27



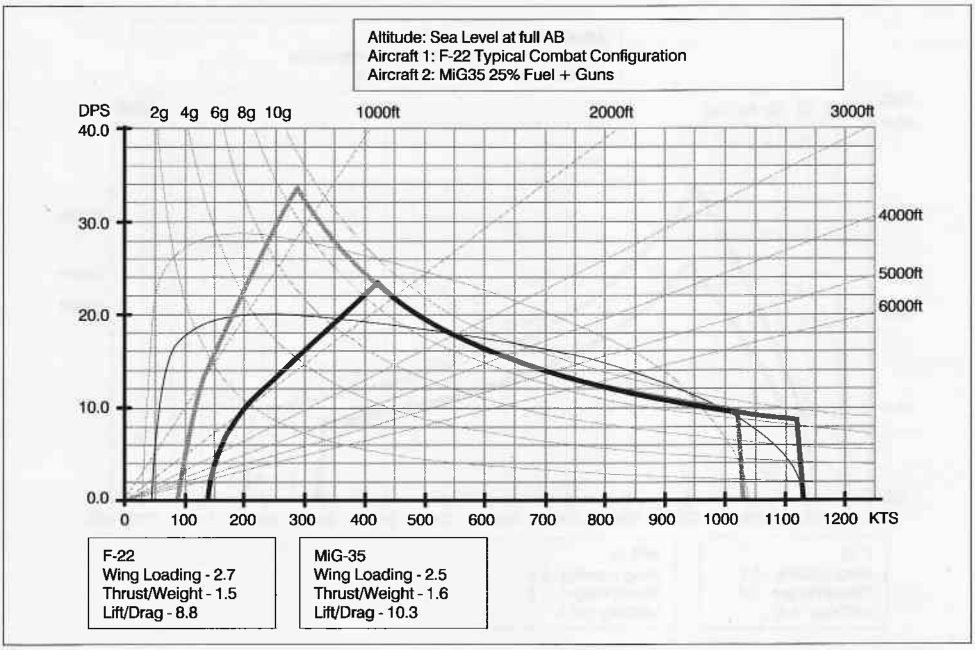
EM Diagram for F-22 v MiG-21



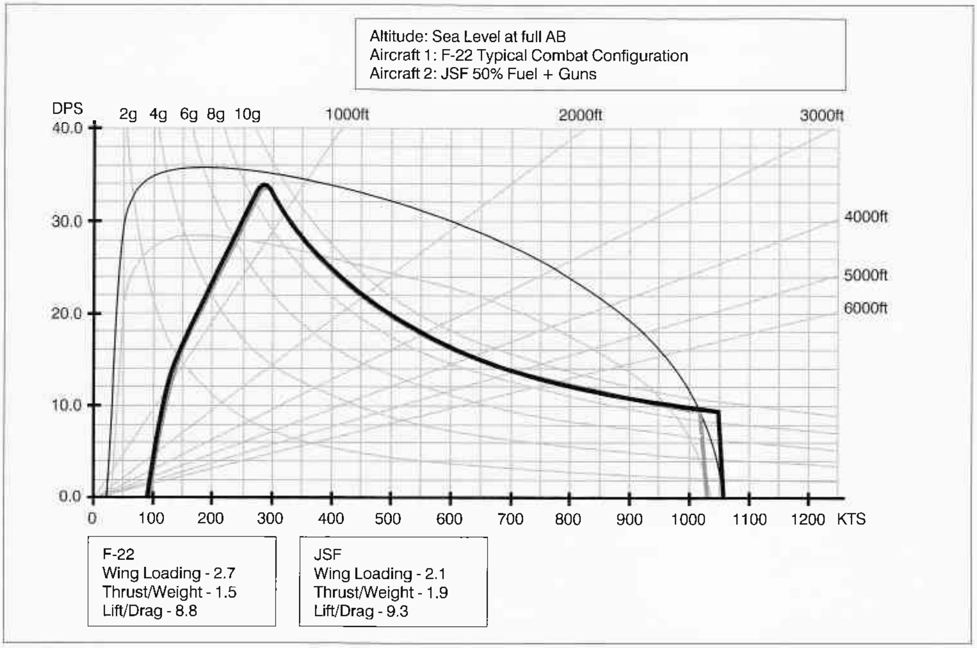
EM Diagram for F-22 v Rafale



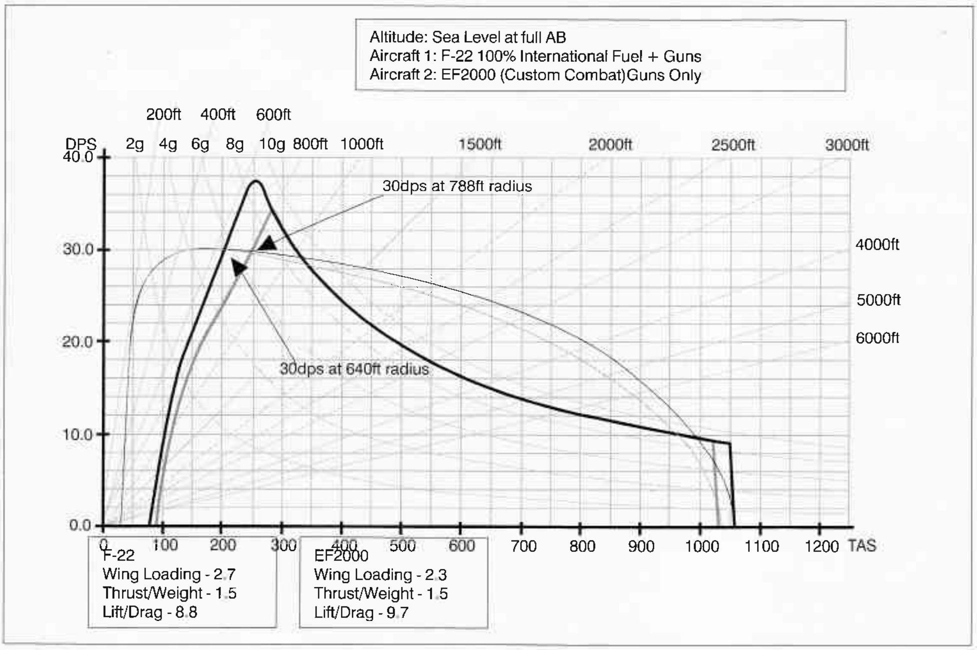
EM Diagram for F-22 v MiG-35

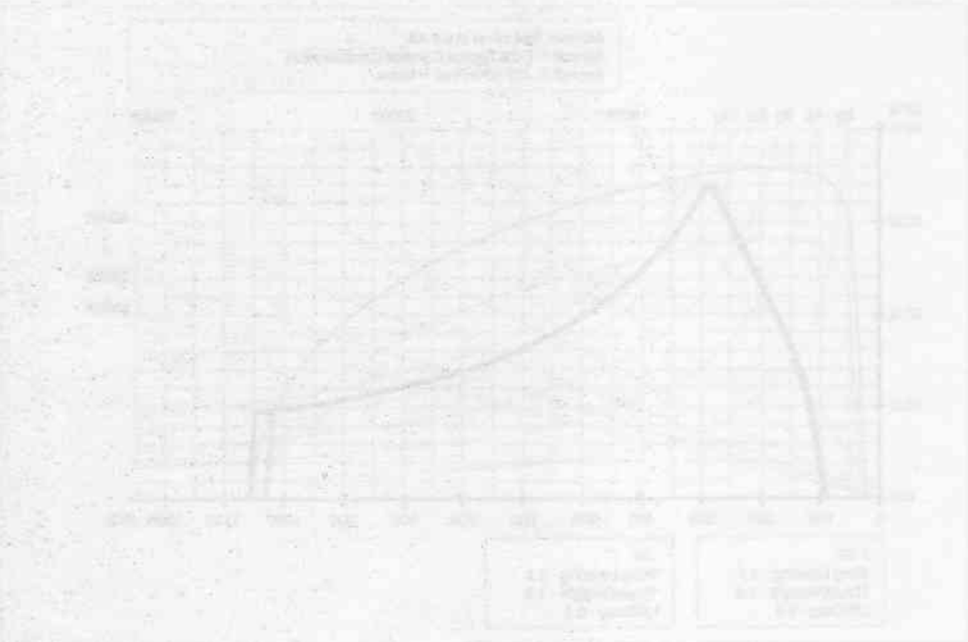


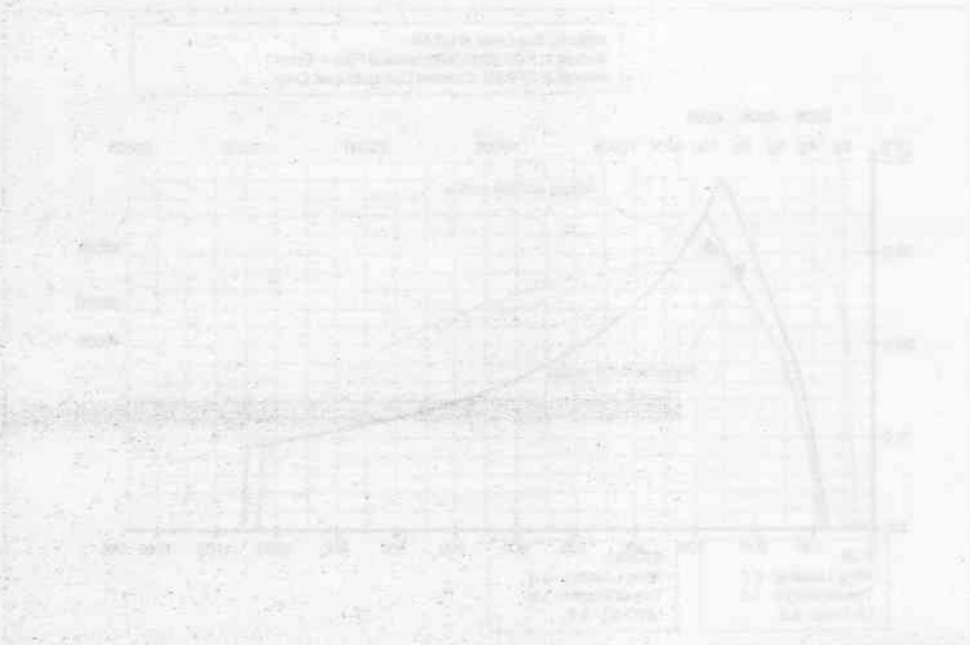
EM Diagram for F-22 v JSF



EM Diagram for F-22 v EF2000







Chapter 11

CAMPAIGNS

CHAPTER 11

Chapter 11 Campaigns

Well, after all the training and TOD missions, you have finally arrived in the Major league – it is time to start with the campaigns.

In TAW, you can choose from ten different scenarios, although only four will be initially available. You have to 'earn' the right to access the other six, more difficult scenarios by succeeding in the easier ones first. Do not worry, with the help of this chapter, you will unlock the six advanced scenarios pretty quickly. However, if you want to hit the advanced campaigns right from the start, you can download a pilot logfile from DID's website (www.did.com) which will enable you to access all campaigns immediately. In addition, the file from DID will also allow you to fly the 'harder' missions as soon as you start a campaign.

Becoming an ace – getting your pilot rating up

Although DID have provided an easy way to gain access to all missions and campaigns, there are still those amongst us who would consider using the points accumulated by someone else as cheating. For those, we will provide a fast (but honest) way to earn the needed points yourself.

The biggest initial hurdle you face in taking a decisive role in the war effort is the fact that you start out as 'one F-22' rookie, and that the types of missions you can fly are thus severely limited. At first, you will only be allowed to participate in backwater CAPs, low value escorts, scramble and the AWACS command missions, all of which, at face value, do not exactly promise to net the necessary points to advance quickly through the ranks.

However, there are ways to get a lot more points than the meagre amount offered in the mission briefing.

The TAW manual states that scramble missions are well suited to get a lot of points in a hurry. If you think 100-150 points are a lot, then that statement is true. However, apart from the negative impact of having to skip forward in time until a scramble mission comes up, time in which the enemy can inflict severe damage, there are two other mission types that are more lucrative. CAPs and the AWACS command missions. Let us take a look at a typical entry-level CAP mission first.

Vigilante CAP mission

Though those 'one F-22' type CAP missions do not offer much in the way of a mission score, you should keep in mind each enemy plane you destroy adds 15 points to your additional score. As you can see in Figure 1, the CAP mission we selected does not look exactly promising with regards to action and thus, points. And even if it was, A2A combat has the definite disadvantage that the enemy rarely comes unarmed to the party, in fact A2A combat can be downright detrimental to your virtual health.

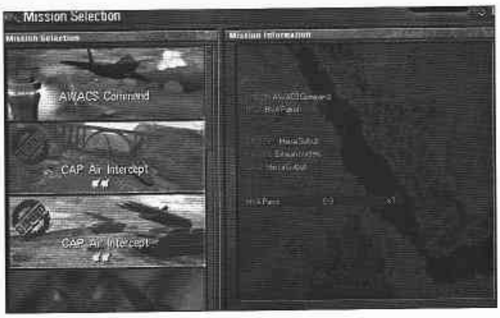


Figure 1: Initial Mission Selection

Therefore, we will look for easier ways to improve the additional score. In this context, it is worth noting that you will be credited with the 15 points for the destruction of an enemy plane irrespective of where you have destroyed it - in the air or on the ground. Given these two alternatives, you should always go for the ground kill – strafing a static object on the ground is a lot easier than killing the same in the air, where it twists and turns and

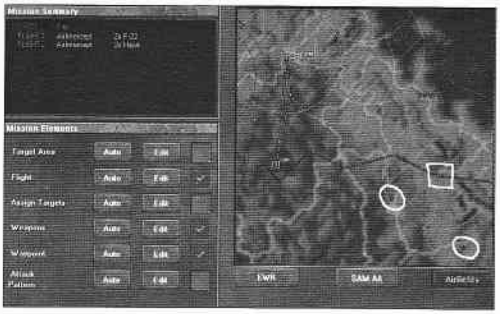


Figure 2: Unchanged Flight Plan

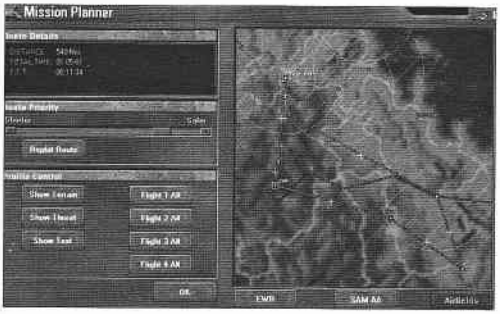


Figure 3: Adjusted Flight Plan

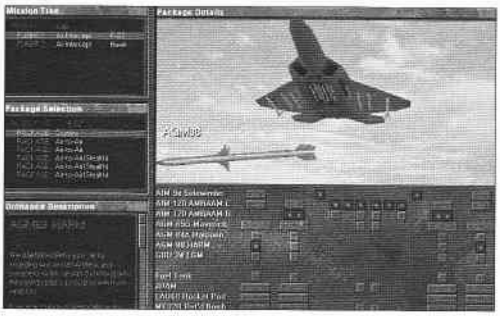


Figure 4: Arming the plane

might even take a pot-shot at you. Thus, when planning a CAP mission, we should always look out for those enemy plane parking places.

If you look at Figure 2, you will note two enemy air bases fairly close to your CAP waypoint, the two white circles, which are also conveniently close to an allied, rearmament base, white square. We will therefore adjust our flight plan to cover these points.

Although it is not strictly necessary to put waypoints over our points of interest, it will make finding them a lot easier once you are up in the air and restricted to the 200 mile circle of your MFD map.

The one catch in this plan is the fact that the enemy is also aware his planes are a lot more vulnerable on the ground and it is therefore likely you will find the airbases defended by SAMs and AAA. With that in mind, we will now proceed to arm our plane for the 'Vigilante' CAP, or VCAP.

Since your primary mission purpose is still air combat, you should load up your plane with as much A2A ordnance as possible. Although carrying external ordnance means compromising the stealthy nature of your plane, for these missions it is essential. You can always regain your stealth advantage by jettisoning the external stores. Also, by using your threat display to manoeuvre around the enemy radar coverage, you can still avoid detection whilst carrying external ordnance. Last but not least, even if you go for a head to head confrontation with the enemy, you will regain your stealthy characteristics after you have fired the first missile volley, at which point you can still exit from the fight to reengage under more favourable terms.

However, with our secondary vigilante goal in mind, you should also take two HARMs into the fight to take out the enemy air defences around the air bases (Figure 4). Furthermore, if you think you can get away with it (or rather, with even less A2A ordnance), cluster bombs are definitely the weapon of choice whenever loosely spaced, soft ground mobiles (like aircraft) have to be taken out.

On the other hand, dumb bombs (or any bombs, for that matter) are of no use if you want to hand off targets to your wingmen. Since the patched version of TAW will rearm your wingman as well, you will have to consider the likelihood of your wingmen making it to your rearmament base once or twice. If you think it likely they will still be

with you, you should select a weapons loadout which maximises your wingmen's effectiveness - which means lots of Mavericks. However, if you are not convinced they will make it back, stay with whatever you feel most comfortable with.

If you become occupied with air combat, you can jettison your external ordnance to hide from preying enemy radars, but carrying it in the first place means you will get it again when you land at a friendly base to rearm. The point is 'ALWAYS ARM YOUR PLANE WITH REARMING IN MIND'.

Once you have adjusted the waypoints and armed your plane, you are ready for the fight.

Executing the VCAP

However, even before you have left the ground, you might run into one of the few really serious bugs in F-22 TAW, the 'Refusal-to-taxi' bug, which means that unless you time-skip onto the runway SHIFT - S , your wingmen might never leave their parking positions. DID have published a detailed taxi-procedure to follow, but to be honest, it is virtually impossible to get wingmen off the ground if you try to taxi manually to the runway. What is even more annoying is the fact that engaging the autopilot in takeoff-mode does not work either, which may be the underlying cause of the problem, since your wingmen use the autopilot logic all the time. The only sure-fire way to get everybody into the air is to time-skip onto the runway. Unfortunately, this is not always possible, if your base is under attack or enemy fighters are close, you will get the 'Cannot skip – under threat' message – in which case you basically have to try to finish the mission alone. You can try to get your wingmen off the ground by issuing the 'DISENGAGE' command. If they receive that message whilst they are still on the ground, they will attempt an emergency takeoff – cross country or rather, cross base. If they do not run into anything until they have reached takeoff velocity, congratulations. Unfortunately, the 'DISENGAGE' command usually results in an early demise off your wingmen. Another way to get your wingmen off the ground is to eliminate the threat – if you kill all the enemy aircraft in the vicinity of your airbase, SHIFT - S might work again (in which case you will suddenly find yourself back on the ground, next to your wingmen). However, at the time of writing, DID had furnished us with a beta version of the TAW patch they were working on, and the taxi problem had already been eliminated.

But for the sake of the argument and for getting along in this chapter, let us assume you time-skipped successfully onto the runway and performed a flawless formation takeoff. Once you are in the air, the first order of business is to ensure that you will be credited with your accomplishments, which, in TAW, means that you have to fulfil

certain completion conditions. For a CAP mission, you usually have to survive, land back at your base and pass the CAP waypoint. Landing back at your base sort of implies the survival, so the one thing you really have to take care of is passing the CAP waypoint, which you should ideally try to get done as soon as possible. For one thing, you might get thrown off your route during the mission and flying a detour just to pass a waypoint certainly falls squarely into the nuisance department. In addition, you might also incur some damage during the mission which might make it impossible to return to your takeoff base, and having one more completion event checked might constitute the difference between losing a mission and saving at least some of your efforts.

After checking the pass event, confirmed by looking at the in-flight briefing, it is time to go offensive, but, with a caution. Remember, the point of this exercise is to rack up kills as fast as possible, not to impress anybody with superbly flown close-quarter air combat manoeuvres. In TAW, the way to accomplish this is by using hit and run tactics.

If you face, for example, an enemy strike group consisting of between 16-24 Su-27s, not too unlikely in the opening hours of a campaign, wading into the fight like the John Wayne will certainly result in a very exciting fight – until you die.

A more appropriate tactic in such a case would be to use the threat display to manoeuvre around the enemy group to close from the stern. In case you are still carrying your HARMs, jettison them before you get close to the enemy, you have to switch to EMCON 2 to jettison ordnance. Except for this, stay at manual EMCON 1 all the time and close until you are in optimum missile firing range, around 17-20 miles. Go to EMCON 3, order your wingman to engage, fire all your long-range missiles in one quick volley, order your wingman to disengage, switch to EMCON 1 and get out of Dodge. Do not hang around to see how well your missile barrage will do, instead, head for the nearest friendly air base as fast as possible. Land, rearm and reengage the enemy flight as before.

By using this missile shuttling tactic, you can easily reduce numerous enemy flights to their component parts without getting shot at yourself - perhaps not too exciting, but certainly effective.

Once all enemy air threats have been taken care off, it is time to remember those HARMs you have been lugging around for a while and set a course towards the enemy air bases you have put into your flight plan. Approach them with caution, since the enemy air defences are just waiting for someone to blunder into range. Select the HARM as your active weapon and build a shoot list as soon as the first enemy radars come up. If your wingman is still with you order him to engage the first threats and save your missiles for those he might miss. In case

you run out of anti-radar missiles before all relevant threats around the strafing range of your choice have been cleared off the plate, I would suggest that you return to an allied base to rearm before you continue. The plan is to spend an enjoyable afternoon, morning, late evening or whatever strafing enemy planes – not to dodge SAMs and AAA shells.

After you have eliminated the enemy air defence units, proceed to destroy the enemy flight hardware. Do not attempt to destroy as many planes as possible in one pass by hosing the area with your cannon, you will just waste your ammunition. It is certainly more effective to concentrate on one or two planes per pass. Even if it takes a bit longer, it will certainly be faster than having to return to your rearmament base a couple of times just because you have run out of rounds for your cannon.

Ideally concentrate on the planes with armament hanging on their hardpoints, those are the planes that may not have been on a mission yet. In addition to the plane kill, destroying them will also result in a mission kill and although you will not be rewarded with any additional points, it will still help to win the campaign. Although you could probably do this all day, it is generally sufficient if you stop doing this after you are at 30+ kills for the mission. At 15 points per plane, this should net you a little more than 500 points – enough for the first promotion, and two more of these missions will secure you the second promotion in no time.

Advanced VCAPs

If you want to go beyond just enhancing your pilot rating at this early stage, you can also execute the VCAP missions in a way that will hurt the enemy's capability to carry out its warfighting plans even more seriously than just destroying its aircraft. As satisfying as strafing and destroying aircraft might be - it will only have a temporary influence on the enemy's strength. Although the planes you destroy will obviously not be carrying out their missions, they will ultimately be replaced.

On the other hand, airbases and buildings will not be repaired. As an isolated fact, already interesting enough. However, the damage level of an airbase influences the operations it can sustain. If an airbases's damage level rises above 60 percent, it will not scramble fighters anymore (and the threat circle around it in the war room will vanish). In addition, there is a relationship between an airbases's damage level and the ratio of fighters tasked for a mission that can actually still be launched. Although the ratio is not linear, it still means a mission that would encompass 16 fighters coming of an undamaged airbase will

definitely be launched with less, and the higher the damage, the smaller the number of actually launched fighters will be.

An airbases's damage level depends not only on the damage to the buildings at the base itself, the damage to nearby, 'supporting' buildings (like, for example, a power station) is taken into account as well. If you want to expand on the basic VCAP mission, you obviously have to adjust your armament load. In order to seriously damage an airbase, you have to carry something that can

- destroy buildings in TAW
- be carried in sufficient numbers
- in addition to the ARMs already mentioned.

Two weapons which fit this bill nicely are the Mk 83F and the LAU-68 rocket pods. However, in case you are not too much into this low-level, paint scrapping flying, there is still an alternative.

The Mighty Mouse – Controlling the war from the AWACS

With the introduction of the AWACS command interface, DID have introduced a new weapon into the air combat arena - the mouse.

Generally, the AWACS command missions are accessible throughout the whole course of a campaign, in fact, you could play a whole campaign just from the AWACS interface, without ever flying a mission yourself. However, due to the way success is determined in TAW, there are times when selecting an AWACS mission is a good idea and there are also times when they are better left alone.

In an AWACS mission, you gain points for intercepting and/or destroying enemy flights and you lose points when allied flights are shot down. Therefore, there is not a great deal to win when enemy air activity is low, as it typically will be after a couple of days of campaigning, provided you have not botched too many VCAP missions during those days. By the same token, it is also not very advisable to select an AWACS command mission if the enemy still has a lot of hardware left but your side does not – without a good number of CAPs airborne, you will not have the means to disturb the enemy's plans to the extent where you can earn a decent score. The best time to select an AWACS command mission is therefore during a time where enemy air activity is high and where you also still have the means to do something about it. Both conditions are usually met during the opening phase of a campaign – which is also a time where access to the high value missions will still be denied to you.

However, sometimes it will only become apparent that the preconditions mentioned above are not met after you have already

entered an AWACS mission. But since an AWACS only 'counts' after 30 minutes, you can abort an AWACS mission at any point in time before that time has elapsed, you will not be penalised, you will just gain no points. But let us assume you will meet favourable conditions - we will now look at how to maximise the score of an AWACS command mission under those circumstances.

Active and Inactive Logic

In order to execute an AWACS mission as efficiently as possible, we have to look a bit 'under the hood' of TAW. To run a game where thousands of objects are simulated, it is necessary to make a few concessions regarding how realistically these objects are simulated. If each and every object was simulated according to physical laws and each and every engagement was calculated right down to the last bullet fired, you would probably see a screen update once every 10 minutes or even less – not exactly what you would like to see in a flight simulation. Hence, the aforementioned shortcuts. There are different ways to accomplish this. Some game manufacturers simply restrict the number of objects which appear, those are the games where you feel quite lonely after a while because the feeling of a real, busy world just is not there. Another solution is to somehow restrict the number of objects for which these high fidelity calculations are made and one of the ways to implement this restriction is to simulate only the objects which are within a certain distance of the player, and to use less precise but faster algorithms for those objects outside of this radius. For the player flying along through the simulated world, this solution is pretty transparent. The events he or she can witness, either visually or by other means, will appear to unfold logically and with the expected results, whereas the events outside his immediate sphere of observation will still be determined logically, albeit less precisely. DID have used this approach in TAW, and the programmers and designers at DID have coined the two different methods to simulate events 'Active Logic' and 'Inactive Logic'.

Unfortunately, there is a catch. With the AWACS command missions, where the whole simulated world lies before the player for immediate access, this approach does not work quite as flawlessly as it does when the player sits in his F-22. During the following section, we will point out where the inactive logic pops in to make your simulated life both easier and more difficult.

Defending your realm

During a typical campaign opening scenario, the enemy will usually send a couple of large strike packages your way, see Figure 5.

Somewhat logically, it would not make much sense to send just a single CAP flight against such a large number of enemy planes and

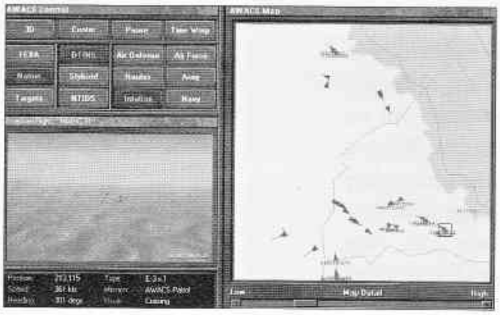


Figure 5: Incoming train

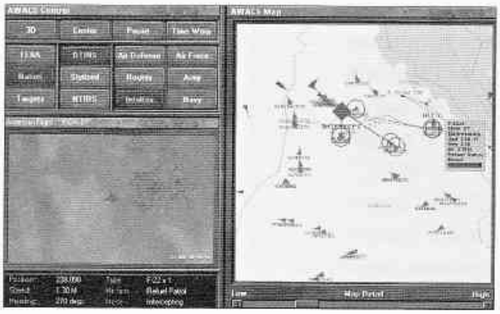


Figure 6: F-22 Active

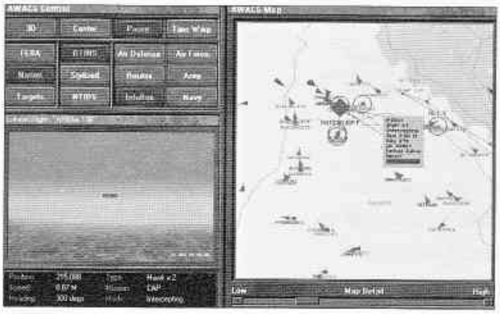


Figure 7: F-22 Inactive

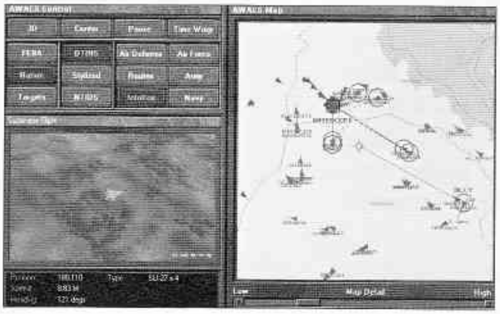


Figure 8: Reassigning CAP areas

thus, one of the most important aspects of the AWACS command is to concentrate your forces to get as much firepower as possible to bear.

One problem with generating a large number of intercept orders in the AWACS, or any large number of orders for that matter, is that TAW generates a message for each of these orders. Whilst this certainly adds to the atmosphere and is also realistic, the time it takes to voice all these messages is certainly a bit on the long side. However, if you double-click on the enemy group over which you have dragged the intercept symbol, TAW will immediately execute the intercept order without generating the accompanying speech message, and your forces will be significantly faster on their way.

Another way to speed up the intercepts is not to focus (do not bring up the flight in the small window) on any of the intercepting flights. The reason for this is one of the active/inactive logic snags. If you focus on a flight, its interaction with the world will be calculated by the algorithms of the active logic, whereas the unfocussed flights will be handled by the inactive logic. At face value, no problem. However, almost all planes fly a lot faster if they are handled by the inactive logic. In Figures 6 and 7 you can see the difference for an F-22.

If the F-22 flight is handled by the active logic, its speed is Mach 1.30, whilst it can go Mach 2.00 under the control of the inactive logic. Note that moving the mouse over a flight to bring up the information box does not place a flight under the control of the active logic. Only if you click on a flight and it comes up in the small window will the active logic be in control of that particular flight and all objects surrounding it within a certain distance.

After you have assigned the first wave of intercept flights, you have to ensure that you will not run out of aircraft during the upcoming battle. Usually, you will have a number of CAPs at places where they will hardly ever be needed, and you should move those backwater CAPs closer towards the action next, see Figure 8.

After these preliminaries have been done, you ought to monitor the ensuing battles carefully. Sometimes, the AI flights revert back to the cruising

mode, and you have to order them to reengage by assigning them another intercept to get them back into the fight. Another advantage of close monitoring (for example, focusing on one of the engaged flights) is that it will 'wake up' the ground units in the area, especially any air defence units that might be deployed around the battle area. Waking up in this context means that the ground objects do not act unless they are controlled by the active logic. You can derive two things from this. First – if you are concerned with enemy aircraft over your own territory, always bring them into focus. On the other hand, if an allied flight approaches a defended target, do not put it into focus.

The next problem you will face during an AWACS mission is whether to fly or not to fly, meaning whether you ought to jump into an available F-22 or not. Although you will lose sight of the big picture whilst you are in the cockpit, do it by all means. First off, you will probably be a better pilot than your AI comrades. Secondly, the AI usually does not know when to quit, once they have entered a fight, they tend to stay. Thirdly, the AI is order-bound. From the AWACS command interface, you will not convince an allied F-22 Wild Weasel or strike flight to engage enemy fighters. However, from the cockpit, you can engage whatever you please and, even more important, order your wingmen to do the same. And last but not least, there is one thing the AI definitely cannot do – that is, rearming an F-22 and getting back into the fight with a fresh weapons loadout.

From the advantages outlined above, it should be obvious that even a single F-22 is a very important asset in an AWACS mission and unfortunately, a single F-22 might be all you get. Therefore, do not waste them/it unnecessarily. Do not wait until the F-22 is already engaged before you enter the cockpit, you will lose the option to decide when and on which terms the fight starts. If you have committed yourself to a fight, handle the engagement like you would do in an F-22 mission – do not overstay your welcome. Use stealth and your long range missiles to stay outside of the dogfight ranges and once you are out of long range missiles, take a long and hard look at the tactical situation. If you are still facing hordes of well armed enemy fighters, bugging out to rearm your F-22 would definitely be the better part of valour.

The next thing to keep in mind is that even a game which offers multiple points of presence does not allow you to be in two places at the same time. Less cryptically, this means that if you have more than one flight of F-22s, you should ideally try to stagger their engagements so that you can take control of each flight as it enters its respective fight.

Keep all the above in mind and the effectiveness of the enemy's attacks should be significantly reduced. In the next section, we will look at how to improve the chances for the allied strike flights.

Turning the tide

You can bet the farm that the enemy will work at least as hard as you to prevent strike groups from reaching their assigned targets. CAPs will be vectored towards them, and airfields along the route will scramble alert fighters which will add their missiles to the running battle as the strike flights proceed into enemy territory.

On the offensive, you have to think even more ahead than you have to in the defensive battle for the simple fact that the point of interest usually moves away from your territory, making it progressively harder to bring in reinforcements in time.

Figure 9: Route of the Strike flight

A typical allied strike flight usually consists of four flights, with the tasks of Strike, Escort and Wild Weaselling distributed between them. Even if two of the groups are the designated escorts, they will be hardpressed to repel several attack waves of enemy interceptors. Fortunately, there are a couple of ways to enhance the defensive firepower of the strike group.

Figure 9 shows a typical scenario in which a strike group has to fight its way into enemy territory. The first step is to reduce the number of threats the strike group has to face. We will accomplish this by retasking several CAPs to conduct a fighter sweep into enemy territory along the route of the strike group, eliminating likely tasks along the way.

Figure 10: Setting up the sweeps

Figure 10 shows how to redirect allied CAP flights to take out enemy CAPs before the strike group enters their respective patrol areas. Although this will reduce the number of threatening enemy fighters that we know of at this point, it is a bit more difficult to calculate how many alert fighters will be scrambled once the strike group has entered enemy territory.

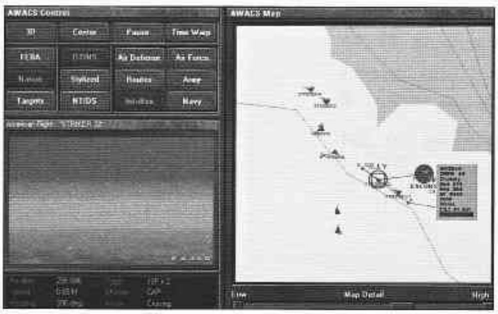


Figure 11: Additional Escorts

In order to be prepared for all eventualities, you can also assign additional allied CAPs or the Escorts of flights which are unlikely to be threatened, like supply or refueller patrols, to escort the strike group, (Figure 11).

By beefing up the escort in such a way, even a couple of scrambled enemy flights are not likely to get past the escorts.

Whether it is a good idea to assign an F-22 flight as additional escorts depends largely on the

circumstances. If you are low on F-22s, sending one deep into enemy territory will nullify its rearmament advantage – you would have to fight with what you have on board, since speeding back to an allied base and trying to catch up again will not work if the flight path of the strike group leads more or less straight away from the border. In such a case, it would be better to assign more non F-22 flights to escort the strike group and to use the F-22s to fill the gaps – fighting close to its rearmament bases, with you at the controls should be enough of an advantage to set off the reduction in numbers incurred by sending of the CAPs with the strike group.

On the other hand, if you happen to have a couple of F-22s to spare, attach them to strike groups by all means, they will definitely enhance the group's defensive potential.

And no matter whether you prefer VCAPs or AWACS command missions, your player score should now grow quite rapidly. Reason enough to have a look at what you can do when you have finally accumulated enough points to take part in the high-value missions.

High Value Strikes – A Survival Guide

If you have not been quite sure whether A2A or A2G missions were the more important missions, the score ratio between the missions involving blowing enemy hardware up and those without any ground action should clear any doubts still lingering in your mind - air to ground combat is the only way to really hurt the enemy.

In TAW, DID have simulated this quite realistically. The war engine in TAW generates strike missions by following the rules of the latest American strategy for conducting a strategic air campaign – the so called 'Centres of Gravity' theory. Used for the first time during the Gulf War, the theory stipulates that each nation has certain classes of key targets, whose destruction will render it incapable of continuing the fight.

In TAW, it will generally be necessary to destroy a certain percentage of a given target class, very often within a certain time span. These time spans can be rather short, and in order to succeed, you have to maximise the mayhem you deliver during each mission. Table 1 shows which targets are of what importance depending on the current strategy.

Mission Selection

In order to ensure the high value targets of the current strategy will be destroyed, you should always try to select missions in which you are

Table 1

	Army	AF	Navy	C4	POL	PIT	IND	INF
Primary Targets	Air Force HQ	Control Tower	Navy HQ	Communication Antenna EWR Control Building	Oil Rig	Multistory Office Building	Factory, Industrial Building	Power Station, Dam
Secondary Targets	Underground Bunker	Hardened Hanger, Pavilion, Terminal, Air Force HQ	Dockside Crane, Jetty	Radar Building, Air Defense HQ, EWR Dish, Dome Comms Building	Oil Refinery Station, Oil Well	Residential Block Residential Building	Chimney	Train Station
Tertiary Targets	Munitions Building	Hanger	Dock	Command Bunker, Communication Building Communication HQ	Oil Derrick, Oil Pipeline, Cracker		Warehouse	Cooling Tower Desalination Buiding Desalination Pipeline

the Strike element. In missions coined 'Interdiction Escort', 'BAI Escort', 'SEAD Wild Weasel' or 'Airfield Denial' success does not depend on whether the strike flight hits the target, but rather on the survival of the Strike element. This means even if you were tasked with surpressing the air defences around the target and you executed this task flawlessly, you will still lose if the strike flight gets shot down by enemy interceptors. The same holds true if you were the Escort and SAMs or AAA gets the bombers. Even if you get your sheep back to base and earn a lot of points, that is in itself no guarantee that the strike flight has successfully destroyed the target, they still miss occasionally. And points is not what you should look out for, maximising the damage level within the current target class is what counts towards success. Therefore, always select a Strike mission. If the current mission list only holds Escort and Wild Weasel missions, hitting 'Cancel' to go back to the war room and selecting 'Fly' again should change the mission list. If it does not work on the first try, repeat the procedure until the mission selection contains a Strike mission.

Flight Planning

Once you have selected a mission, it is time to look at what the war engine has come up with. The mission plan depicted in Figure 12, calls for an attack on the city of Khartoum. However, this target has already sustained 62 percent damage, so another attack is not likely to make as much a difference as an attack on a fresh, as yet, unblooded target would do. Although you are not as free in planning your own attacks in TAW as you have been in EF2000 TACTCOM, you can still select a new target for the current mission.

A little searching around reveals a target in the North-East of Sudan, the army post at Bur Sudan. With no attacks currently planned (you do not want to attack a target another allied strike will visit shortly) and still completely undamaged, this is a target where a well planned attack will make a significant difference.

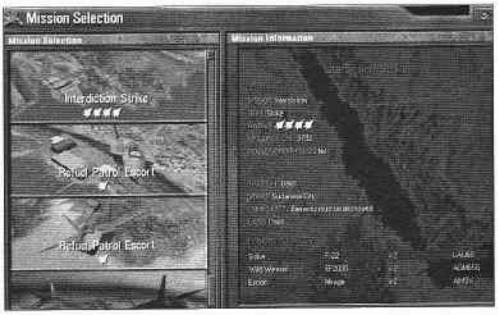


Figure 12: One Strike Mission coming up

For this mission, the war engine has allocated 2 EF2000s and 2 Mirages as your Wild Weasel and Escort flights. Although both are good, capable planes, they share a common disadvantage – they are not stealthy.

Figure 13:Unstealthy Flight

In Figure 13, you can see the implication of this problem – your flight can be easily detected by early warning radars, SAM/AAA sites and, although not apparent from this picture, enemy interceptors.

Therefore, your first change should be to replace the EF2000s and Mirages with stealthy planes. Although you will not always get enough F-22s to fill up your flights, there are still the JSF, the B2 and the F-117A, although the latter two would only be useful in the strike role. In our example mission, there are no more F-22s available, and we will therefore use 4 Joint Strike Fighters to fill up the ranks.

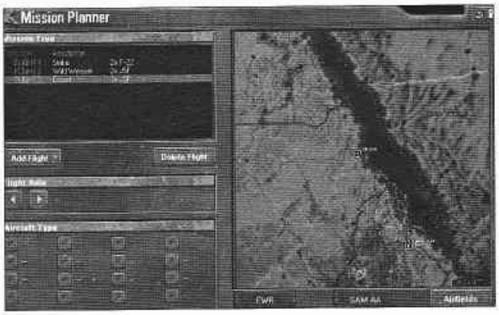


Figure 14: Stealthy flight

A second consideration may be to change the flight roles. Although you will never get more flights than the war engine has initially allocated for the task, you are free to assign each flight the role you want. Depending on the enemy air threat, you might forego the Escort to get another Strike flight. The same goes for the Wild Weasels – if the target is not defended by SAMs and AAA, there is definitely no point in assigning a flight to fight a non-existent threat.

As you can see in Figure 14, replacing the unstealthy planes has reduced the effectiveness of the enemy radar systems quite significantly.

As the next step, we will adjust the route for the flight. If you like to use time skip **SHIFT - S** to advance past the less interesting parts, you should plan the route to stay out of enemy territory as long as possible. As soon as you enter enemy air space, you will be mysteriously detected by the enemy AWACS, and the program will evaluate this as you being under threat and hence – no more time skipping will be possible. In addition, you will usually not take off from the base closest

to your target, (especially if you have changed the target) and you should therefore always put a waypoint over the allied airbase closest to your target. If you do, you will not have to search around for a rearmament base or even have to fly all the way back to your takeoff base to replenish your weapons load.

In our example, it is also easy to see that the target complex is not defended by any SAMs or AAA, so we do not need to select a soft secondary target to employ our additional ordnance, more on that in the armament section.

Another consideration when planning the route is that you should avoid leading your flight through enemy EWR coverage or within the engagement ranges of SAMs/AAA.

Arming for the Mission

Speaking of weapons load, as with the VCAP missions, you should choose your weapons for a Strike mission with rearming in mind as well. However, for the campaign, things are bit more complicated.

For a campaign Strike mission, we will differentiate between the primary and secondary armament loadout.

Primary Loadout

On a campaign mission, you have to expect the worst case just to be on the safe side. In the context of a Strike mission, this means that you either start without Escort and Wild Weasel flights or that you lose them on the inbound leg of your flight.

The primary loadout for a campaign mission has to consist of the tools necessary to get the job done all by yourself. Staying stealthy to avoid detection by the enemy is therefore paramount to all other considerations and thus, all weapons will have to be carried internally.

The most capable air to ground weapon you can carry internally is the JDAM. With a range of up to 30 miles when released with the toss manoeuvre (described in part II of Chapter 7, 'Advanced A2G Combat'), it enables you take out each and every static target in TAW without getting even close to being fired upon by air defences around the target. Due to its GPS guidance it will find its target without any need for further action by you other than to place it within gliding distance of the target. The only real downside of the JDAM is that it cannot be retargetted, it will always go for the primary target.

The other internal weapon slots should be filled with A2A weapons. Although you should seek to avoid a confrontation with enemy fighters - the few additional points you may gain by shooting them down do not justify the risk of failing the mission in case they get you -

A2A combat is sometimes unavoidable in order to get close enough to the target to release the JDAM.

The most capable A2A loadout you can carry internally in addition to the JDAM consist of 2 AIM-120Rs, 2 AIM-120Cs and two Sidewinders, except for when you are attacking command bunkers, which need 2 JDAMs and you have to reduce the A2A loadout to make room for the second JDAM.

Secondary Loadout

The secondary loadout consists of the weapons you can use to wreak additional havoc during your strike mission, but which you ought to jettison at the first sign of being detected by enemy fighters. In TAW, this means taking out as many additional targets belonging to the current primary target class as possible. Those targets need not be necessarily close to your primary target. If a suitable, lightly defended target can be found, include it in your flight plan. Logically, this means you have to carry additional bombs externally, with which you will lose your stealth advantage and thus more defensive weapons may be needed to get you past the enemy defences.

As you can see, selecting a suitable secondary loadout is not as clear-cut as selecting the primary loadout. First, there is the matter of which kind of bombs you prefer, dumb or laser-guided. We recommend the Mk 83F, because everything but a hardened aircraft shelter needs only one of those to be completely destroyed. In addition, up to 12 can be carried, so even one additional visit to the target area may be enough to destroy each and every target in the complex.

However, tastes and to a certain extent capabilities, vary. If you have problems hitting anything with dumb bombs, it does not make much sense to lug them around, use laser-guided bombs instead.

And although you should try to make a second run at either the primary or a soft secondary target (soft meaning undefended by SAMs/AAA) belonging to the same target class, it is not always advisable to do so. Depending on the progress of the campaign, the enemy defences might still be considerable. If you have to take so much additional defensive armament that you can hardly take any additional bombs, the effort might not be worth the risk.

Therefore, select whatever secondary armament you feel appropriate, but do not think that just because you are carrying it, you are under any obligation to use it. If it compromises your primary mission, get rid of it.

Arming the other flights

Except when your company consists solely of F-22s, there is no way to ensure that all your planes will carry their ordnance internally and hence stealthy. Due to the fact that most of the packages for the stealthy planes, especially the JSF, include some external ordnance, your escorts will probably not be quite as stealthy as you are. Which is both good and bad. Bad because your flight might be detected earlier, but, and this is the good part, you will not be. Which means that the enemy will primarily focus on the other flights and you have the option of either bugging out or helping by entering the fight unobserved and from a totally unexpected direction.

However, if you are lucky enough to get enough F-22s, stealth should be your prime consideration when selecting the armament for the other flights.

Now that the preliminaries are taken care of, it is time to do the deed.

Conducting the Strike

Once you are in the mission, you should be clear about what you have to do – destroying your primary target. Everything else is of secondary importance compared to hitting the target and getting back to your base in one piece. The point needs to be stressed because due to the dynamic nature of the campaigns in TAW, it is very easy to be distracted by seemingly easy targets like a flight of supply choppers or a column of tanks slowly proceeding through the desert. However, the missiles you use to shoot down the helicopters might be sorely missed once you meet the hostile CAP over the target, so resist the temptation.

The best way to get to the target and back is to conduct the mission as unconfrontational as possible, meaning that you deliberately try to avoid any contact with the enemy, even if that means you have to fly a detour once in a while. Due to the way the campaigns in TAW work, taking on an innocent and easy to kill flight of two MiG-21s can mean you will inadvertently fly too close to an airbase, which will scramble a couple of Su-35s, who in turn might receive help from another flight of Su-27s and so on. Sounds unlikely? – Wait until your escorts and wingmen are really on the loose, once they are engaged, it is almost impossible to get them to disengage and a good fight draws in other fighters like bright light attracts moths.

Especially during the initial stages of a campaign, avoiding contact with the enemy means you might have to jettison your external ordnance during a very early stage of the flight, sometimes even before you enter enemy territory. Do not hesitate to do so, you can always get

that stuff back by rearming. Once you are detected, engaged and possibly damaged or even shot down, it is too late and you will be left contemplating the what ifs.

In order to avoid unwanted contact with the enemy, it is obviously necessary to detect them early enough to get out of their way. Which brings up the question of time advance – skipping or accelerating?

If you try to stay out of trouble, time skipping is not really a valid option. Although you do get dropped out of it a bit earlier than in EF2000, you can occasionally get skipped smack into the middle of an engagement, or at least close enough to a hostile group to be unable to avoid the confrontation. Therefore you should really only use time acceleration. You will at least retain the ability to detect the enemy early enough and be able to react accordingly.

However, something that is not indicated on your sensors are the detection ranges of the enemy EWR sites and AWACS planes. Both will feed their information into a distribution network and vector interceptors towards both you and other allied flights.

If you kill the enemy AWACS, you will make life a lot easier for all allied flights. And although there are a certain number of replacement AWACS available, this number is definitely finite and not too large to begin with. Thus, if you keep at it, at some point, the enemy will run out of AWACS planes, and the succeeding missions will become a lot easier because the enemy CAPs will have to rely on their own sensors to detect their prey.

The same goes for EWR sites. If you destroy one, it stays destroyed, leaving a gap in the enemy radar coverage. In addition, the war room AI will exploit those gaps and route allied strikes through them.

Keeping the guidelines above in mind, you should have no trouble getting close enough to your target to send the JDAM on its way, which, as we have noted, will destroy the target when released within the proper parameters.

At which point your work is done and you could proceed back towards the base to secure the mission score. However, success in TAW is not based on your score, it is based upon the destruction of a certain percentage of (a) key target class(es). Although you may just have achieved your mission objective, your primary target is usually only one target in an enemy installation. Even if your wingmen and further strike flights have all hit their assigned targets, there are usually still valid targets left and the more you can take out, the better.

However, you should not plunge into this without careful consideration. First question – is it safe? If there are still SAM sites around the target and you do not have enough ARMs to kill all of them, you will probably never get close enough to the target to drop your ordnance without getting shot at. Even more important, do you

still have the means? If you did not have to jettison your secondary armament during the ingress, all the better, you can start to work over the target immediately. If you had to jettison the ordnance, you have to evaluate whether there is a chance to get back to the target after rearming at an allied base and re-entering enemy airspace unstealthy, which should not be too difficult. As you will discover, it is usually markedly more quiet when flying along the same route a second or third time. If taking out further targets is a valid option, you should note that setting the urban detail setting to low makes it a lot easier to find the additional targets.

Battle Damage

Sooner or later it will also happen to you – some incredibly lucky enemy rookie hits with you a shot he or she probably fired inadvertently while groping around the cockpit for the ejection handle. No matter how it happened, battle damage is not to be taken lightly, because it might severely undermine your chances to succeed in the current mission. This is mainly due to the fact how the completion events influence the way your final score will be calculated. Typically, you will have to complete three conditions in a TAW campaign mission, survive, land back at your take off base and a third, mission related condition like passing a waypoint, destroying a target or ensuring the survival of a certain flight.

Only if you 'tick' all conditions will you get a positive score. If you fail one, the mission outcome will be neutral, fail more than one and you will get a hefty negative score which might easily lead to a demotion in rank. Of the three, the condition to land back at your takeoff base has probably been the most annoying restriction in the original release of TAW. Even if you limped back to another allied base, you would still fail the 'Land at...' condition. However, in the patched version, you can adjust your GAME.CFG file to allow you to land at any allied base.

There are also some other factors which influence your score. If you eject over allied territory, the maximum mission score will be reduced by 30 percent, and if you are still over enemy territory when you eject, the penalty rises to 40 percent. Basically, you should always try to save both the plane and the pilot, as the loss of either will have a significant, negative impact on your score.

Therefore, in case you do get hit, you should immediately evaluate how the damage influences your ability/chances of continuing the mission and/or getting back to your, (a) base, after you have fought your way out of the current engagement.

In case of slight damage to the engines, up to loss of burner on both, it is usually possible to continue the mission, you just have to be a bit

more careful. If you have sustained graver damage, like a hydraulics failure, a fuel leak or an almost complete loss of thrust, immediate retreat is the only sensible thing to do. If you happen to be on your way back from the target, congratulations, it might still be possible to save the full score. If it happens on the way in, do not try to be a hero, a neutral outcome is always better than a complete loss.

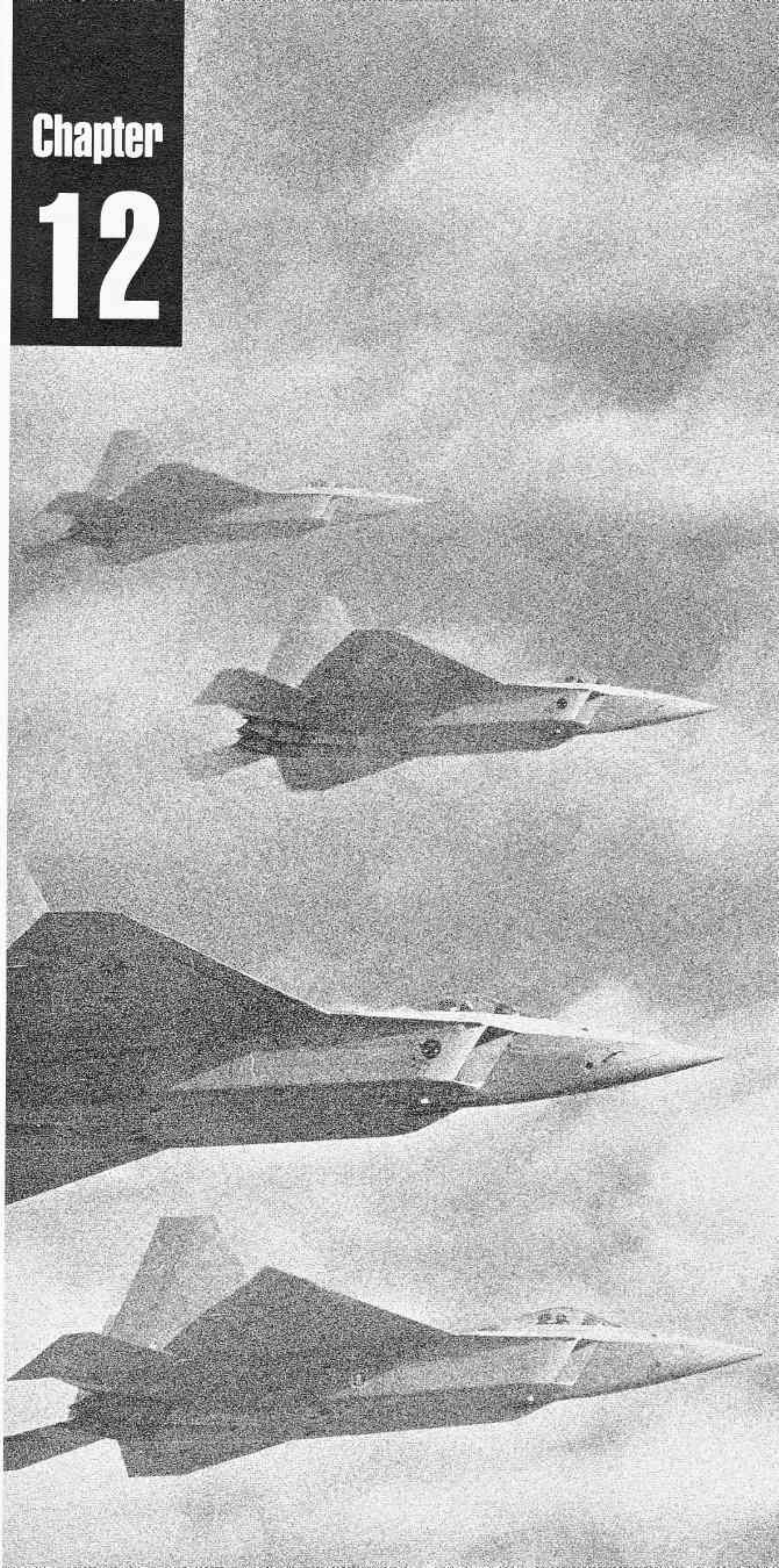
The first thing to do when you get damaged and have to retreat is to jettison all external ordnance, you will hardly be able to afford the additional drag it will incur. Of the bad things which can happen, a fuel leak is probably the worst. If you have one, get as high as possible and prepare yourself for a dead stick landing. Do not panic if you really run out of fuel before you land, you can easily glide for more than 40 miles from 40,000+ feet (see Chapter 3, 'Basic flight').

Unless you were already pretty close to your takeoff base when you were hit, you might have to do a bit of base-hopping to get back – land at the closest allied base, refuel, takeoff and do not forget to jettison the external ordnance again after takeoff and try to make it to the next base. If you feel you will definitely not make it to an allied base, you should still try an emergency landing on some piece of flat ground. Although a landing on something other than your takeoff base will not fulfil the 'Land at..' condition, being on the ground at the end of a mission will fulfil the 'You must be alive' condition. Ejecting will do the same, but, there is such a thing as the pride of saving the aircraft, is there not?

Next on the list is hydraulic failure, which will affect the air brake and gear. The loss of the former is annoying, but not critical, the loss of the gear will make landing the plane definitely more interesting. Even if your hydraulics level drops below the point where you can still extend the gear, you should still attempt the gear-up landing, if you do not blow up in the process, a gear up landing at the right air base will fulfil the 'Land at ..' condition.

However, we hope you will not need to implement the procedures of the battle damage section. Flown intelligently and stealthy, completing successful Strike missions is not too difficult in TAW, and that after reading through this chapter, we think you will agree.

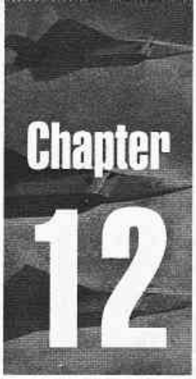
Chapter 12



Network & Modem Play

- Installing and Setting Up a Network
- Installing and Setting Up a Modem
- Making the Connection
- Multi-Player Gaming Scenarios
- CO-OP Mission Scenarios

CHAPTER 12



Network & Modem play

Network and Modem Play

Shooting down computer controlled aircraft is challenging and fun, but shooting down a human opponent is even more so! Nothing compares to the excitement created when friends gather together across a network and fly competitively in head to head encounters, or work cooperatively to accomplish challenging mission goals. If you are serious about combat flight simulation, you should make the effort to try this at least once.

Windows95 makes networking relatively easy, even for the inexperienced. In addition, the cost of network hardware continues to drop, making multi-player gaming more accessible. Of course, you will need to find willing partners, however even if you are not fortunate enough to have other enthusiasts nearby, you can still enjoy the thrill of dogfighting against other human opponents across the Internet, or directly via modem.

F-22 ADF/TAW offers several communications options and scenarios for linked play. Depending on the type of connection employed, up to 8 'everyone for themselves, free for all' games, or cooperatively as teammates flying against other teams. In addition, the new 'Total Air War' version of F-22 offers cooperative, mission-based play for up to 4 players. This chapter will provide an overview these options, as well as the help you need to get up and running. A word of warning however, once you experience it, multi-player gaming can be extremely habit forming!

Part I

Installing and setting up a Network

Network Shopping List

The most common network installations in use today are based on one of two types of Ethernet cabling configurations: Coaxial (10base2) or Twisted Pair (10baseT). Regardless of which configuration you choose, you will need to install a network interface card in your computer and purchase the appropriate network cables. Twisted pair set ups will also require a network 'hub' if you plan on connecting more than two computers together. Coaxial networks are slightly less expensive since no hub is required. However, the cost of network hubs has dropped significantly in recent years, making twisted pair networks both more affordable and more commonplace. There are technical advantages to twisted pair networks that make this the more attractive choice, despite the slight added costs, however both configurations work quite satisfactorily for gaming purposes. The choice you make should be based primarily on what other players in your area are using.

Here is a list of the hardware you will need for a simple network installation using coaxial network interface cards:

- One coaxial (10base2) Ethernet network interface card per computer.
- One 'T' connector per computer (typically provided with the network card).
- Two 50 ohm cable terminators for the entire installation.
- One length of coaxial cables (RG 58A/U with BNC connectors) for the first two computers on the network and one additional cable for each additional computer to be connected.

For twisted pair networks, you will need the following hardware:

- One 'twisted pair' (10baseT) Ethernet network interface card per computer.
- One Ethernet network hub. The number of computers you can interconnect per hub will vary depending on the number of 'ports' available on the hub. If you wish to connect more computers than there are available ports, you will need additional hubs.

- One length of twisted pair cable (Category 5 preferred) with RJ-45 connectors per attached computer.
- A special 'link' connector if you plan on connecting only two computers without a network hub.

A newer, more advanced type of twisted pair network, designated '100baseTX', is now available in addition to the more common 10baseT specification. 100baseTX offers up to ten-times the maximum speed of either its predecessor or coaxial networks. In order to take advantage of this speed increase however, ALL of the connected network cards, as well as the network hub, must be using 100baseTX. As you might expect, these new components, especially the network hubs, cost considerably more than their older cousins did. Whether the increased speed is worth the additional cost is open to debate. While there is no argument that 'faster' is 'better' when it comes to computer hardware, the enhancement offered by 100baseTX is minimal when only a modest number of systems are attached. Unless you are one of those folks that must have the 'latest and greatest', you will do better to spend your money on other system enhancements such as 3D accelerator cards, larger monitors, better joysticks, etc. For the vast majority of users, a 10baseT or 10base2 network set up offers completely adequate performance.

Regardless of which type of network connection you will be using, make sure the network interface card you buy will plug into your machine. Network cards plug into one of two varieties of computer slots, PCI (Peripheral Component Interconnect) or ISA (Industry Standard). In most Pentium class computers, PCI slots are more abundant than ISA, so PCI network cards are preferred. If you opt for an ISA card, look for one that is 'Plug and Play' compatible with the Windows95 operating system in order to simplify configuration of the card.

One final note regarding the network interface card. Purchasing a 'combo' card – one that offers both 10baseT as well as 10base2 connections – is highly recommended. This will provide you with the greatest flexibility when hooking up with other players on a network. With a combo card, you are not limited to a single cabling configuration.

When purchasing a 10baseT network hub, consider how many systems you will be connecting and what additional features you will need. Hubs commonly offer anywhere from 4 to 24 (or more) ports. Since F-22 ADF does not support more than 8 players at any given time, you do not need more than 8 ports. However, even if you buy an 8 port hub, you should make sure that it is 'stackable' - one which allows additional hubs to be linked in order to increase the number of attached systems. For maximum utility and compatibility, also look for hubs that have a BNC uplink connector. This will allow you to

attach computers which have 10base2 network cards installed to your network. If you have, or anticipate using 100baseTX network cards, then your hub will also need to support this protocol in order to take advantage of the extra speed. Be sure that it supports both 10 and 100 Mbps connections so that players with both types of network cards can connect.

Network Hardware Set Up

If you feel you are incapable of installing a network card in your computer, or if doing so yourself would void your computer's warranty, have a professional install it for you. If you choose to install the network card yourself, follow all of the manufacturer's instructions carefully so as not to damage anything.

If you purchased a 'Plug and Play' ISA or PCI network card, you should not need to adjust any jumpers or switches on the card in order for your computer and Window95 to recognise it and adjust the resources accordingly. Carefully install the card, start up Windows and proceed to setting up the necessary software drivers.

If you are installing a 'non-Plug and Play' – also know as 'Legacy' – network card, you may need to adjust IRQ (interrupt) and/or memory address settings on the network card manually in order to avoid conflicts with other devices. Before installation, consult the Device Manager – available through Windows95's System applet in the control panel – to determine which IRQs and memory addresses are available and do no conflict with other resources. Write down what settings are available that match ones your network card uses; you will need to refer to them later.

If your network card is hardware configurable, move the jumpers to the appropriate positions before installing the card in your computer. If your network card is software configurable, install the card first and then run the set up program provided by the manufacturer. Note that you may need to boot to DOS rather than Windows in order to run the set up program.

For Legacy ISA network cards, you may also need to change the settings in your computer's CMOS in order to dedicate the selected IRQ resources to the ISA bus. Your computer manual should provide detailed instruction on how to make these changes. If it does not, consider exchanging the network card for one that is 'Plug and Play' compatible or seeking advice from a professional or the manufacturer's technical support department.

Some 10base2 (coaxial) network cards will fail to be recognised – either by their setup software, or by Windows – if they are not properly terminated. Attach a 'T' connector with terminators on both sides of the 'T' if you are not already plugged into a terminated cable

set up. To avoid problems, always keep your 10base2 network card property terminated.

Network Cabling

Coaxial cables connect the networked computers along a continuous chain. At each end of the chain is a 'T' connector with a terminator attached to one side of the 'T'. Additional 'T' connectors, one for each computer along the chain, are joined with cables. The stem of the 'T' is attached to the BNC connector on the back of the network card. Make sure that all connections are secure.

If you are using twisted pair cabling, each network card is attached to the network hub by its own cable in a 'spoke' configuration. Depending on the type of hub in use, there may or may not be indicator lights that illuminate to show that proper connection is made to each computer.

Cabling is one area where twisted pair networks really shine. Because each computer is using a dedicated cable to communicate with the hub, a single faulty cable or connection will not disrupt the entire network. Troubleshooting is much easier than in coaxial set ups where you might need to swap sections of coaxial cable in and out in order to find the bad piece. In addition, network communications tend to be slightly faster and more efficient on a twisted pair network since everyone is not trying to 'talk' across the same piece of cable at once.

Network Software Set Up

Once the network card is properly installed, Windows95 should automatically recognise it and prompt you for the necessary drivers. You will need both the software disks provided with the network card as well as your Windows95 diskettes or CD-ROM in order to install the necessary network drivers. Follow the on-screen prompts as Windows guides you through the process.

If the network card is PCI and/or 'Plug and Play' compatible, the setup process is fairly automatic. Windows95 should be able to allocate the proper IRQ and memory address resources automatically. If you have a Legacy network card, Windows may not be able to determine what resources it needs to reserve, and will alert you to adjust the IRQ and memory address settings manually. To do so, access the Device Manager – through the System applet in the Control Panel – and find the Network Adapters sub-section. Highlight the network card and select 'Properties'. You should be able to enter the proper IRQ and address settings under the Resources screen. Once you close the Device Manager, you will need to re-start Windows before you can use your network card.

F-22 ADF/TAW uses the IPX/SPX protocol for network play. Windows95 should automatically install this protocol during software set up. You can check this by calling up the Network applet in the Windows95 control panel. Add this protocol if it does not exist for the network card. Once you can access it, highlight the 'IPX/SPX Compatible Protocol' selection for your network card and select 'Properties'. While you are here, you should also check to make sure that 'File Sharing' is enabled.

If everything goes smoothly, you should be able to see other computers connected to the network when you double-click on the 'Network Neighborhood' icon. If you cannot see anyone else, or they cannot see you, check to see whether you have 'File Sharing' enabled. If so, set one of your drives – the floppy drive, or your CD-ROM are safe choices – as 'shared'. This will often do the trick. Refresh the view in the network neighborhood after a moment or two and see if the situation has improved.

If you still cannot see your partners, double-check all the cabling. As noted earlier, most network hubs have lights to indicate that they are communicating with the attached network card. If Windows recognises the card but the light on the hub is dark, try a different cable. If the reverse is true, then you still do not have the networking portion of Windows set up properly.

Finally, you should verify that all the computers are speaking the same language, that is, using the same network protocols. Select the 'Advanced' tab and highlight 'Frame Type'. You should see 'Auto' as the current value. In most cases, this will be fine. It is important, however, that all machines on the network use the same settings in order to connect with each other. If you are having problems with some machines, check the frame type. If they match but problems persist, have everyone select 'Ethernet 802.3' as the frame type. While not a guarantee, this will often solve the problem.

If you continue to have problems connecting to other computers, consult the Windows95 online help system and look under 'Troubleshooting' to find additional help with network connections. Follow the advice provided to diagnose your problem. If all else fails, consult your network card manufacturer's technical support department, or someone who is expert in Windows95 networking.

Part II

Installing and setting up a Modem

Although playing F-22 ADF over a network provides the best performance – as well as the most 'social' experience – it does require that you disassemble your system and transport it to a central location. Playing over a modem allows you to fly from the comfort of your own home, and if you have access to the Internet, the greatest number of opponents. For this reason, modem play, either directly or across the Internet, is currently the most common form of multi-player activity.

Modem Shopping List

These days, most new computers come equipped with modems. Nonetheless, you may have a system that does not include a modem and will need to go out and purchase one. Modems are available in either internal or external configurations. The choice of one over the other is largely a matter of personal preference as their performance is, for all intents, identical.

An internal modem is slightly cheaper due to the fact it does not require a case, power supply or cable. They are also much neater, requiring only a telephone line and avoiding additional boxes, cables and power supplies. However, an internal unit requires an available slot (typically ISA) and IRQ - resources your computer may not have available. External modems require only an available serial port, a resource that is readily available. In addition, external modems are portable and can be moved easily from one computer to another. Most external modems feature activity lights that allow you to follow the progress of your call. This simplifies troubleshooting connection problems.

Whichever style you choose, the primary consideration should be speed, and to a lesser extent, additional features not related to gaming such as fax and/or voice mail capabilities. The recommendation here is simple – buy the fastest modem you can afford. Speed is the single most important determining factor in how smooth your connections will run. At minimum, you should purchase a modem that is able to operate at 28.8 Kbps (kilobaud, or thousands of bits per second). A modem capable of 33.6 Kbps is better. One that runs at 56 Kbps is, by far, the best.

Speed is critical in order to obtain a smooth game play experience. On a network, data is transmitted at speeds measured in million of bits per second - up to ten million for 10base2 or 10baseT networks, up to one hundred million for 100baseTX networks. By comparison, modems transmit data at speeds measured in thousands of bits per second, many times slower than a network. The slower speeds result in a phenomenon known as 'warping'. When warping occurs, planes will seem to jump around the screen as packets of data are lost or become unsynchronised. The faster the connection, the less warping will occur.

Stick with name brand modems as these will usually deliver the best performance and provide the best support after the sale. If you intend to use your modem for Internet connections, consult your local Internet Service Provider (ISP) to find out what brand of modem they use or recommend. In general, you will obtain the best performance if your modem matches those used by your ISP. This is especially true of 56 Kbps modems. Up until now, there have been two competing, and incompatible, types of 56 Kbps modems, X2 (developed by USRobotics/3Com) and KFlex (developed by Rockwell Technologies). As of September 1998, a new standard has been adopted by the International Telecommunications Union (ITU) called V.90. If you are buying a new 56 Kbps modem, make sure that is V.90 compatible. If you have an existing X2 or Kflex modem, contact the manufacturer to find out if an upgrade to the new V.90 standard is available.

The modems described above all operate using normal telephone lines. Two other, special types of modems bear mentioning. These are Integrated Services Digital Network (ISDN) and cable modems. ISDN modems use special phone lines to provide connection speeds of up to 128 Kbps. Cable modems make use of your cable television wiring to provide connection speeds only slightly slower than standard networks – speeds up to one million Kbps are not uncommon. Both of these are primarily intended to provide high speed Internet access. Unfortunately, both of these are considerably more expensive than traditional modems and are not available in all areas. Consult with your telephone, cable television and Internet providers to determine availability and cost.

Given the performance of 56 Kbps modems, ISDN is far less attractive than it used to be considering the cost premiums. Cable modems are, however, nothing short of amazing. If this service is available in your area and you use the Internet heavily, it is definitely worth considering. Be advised that some cable operators only provide high-speed service on the 'incoming' side of the connection and rely on a standard modem connection for 'outgoing' data. While this type of connection is great for 'surfing the net', it is no better – in fact, often worse – than a normal modem connection for interactive gaming.

Modem Hardware Set Up

If you are purchasing an internal modem, you will need to install it into an open slot on your machine. Modems typically occupy an ISA slot, so be sure that you have one available. You will need to set the IRQ and COM port selections prior to installation. Your mouse is probably connected to COM 1 and uses IRQ 4. Modems commonly come configured to use COM 2 and IRQ 3, however you should check your own system prior to installation to ensure you do not create a conflict. A 'Plug and Play' modem is preferred, as these will allow Windows95 to make the necessary settings automatically. If the modem you have is a Legacy card, check the instructions to see what jumpers or switches you may need to set.

Always follow the manufacturer's instructions and cautions when installing your modem. As with network cards, if you are uncomfortable with installing a modem in your system by yourself or if warranty restrictions forbid you to do so, have your dealer install the modem for you.

If you purchase an external modem, you will also need to a serial data cable that matches the ports on both the modem and your system. Serial ports come in both 9 and 25 pin varieties. Make sure you have the proper cable.

For ISDN or cable modems, consult the manufacturer, telephone company or cable provider for specialised instructions on installation and connection.

Modem Software Set Up

F-22 ADF uses the Windows95 interface to communicate with the modem. Have any disks that came with your modem available and follow the instructions provided by the modem manufacturer. As with network cards, Windows does a decent job of recognising 'Plug and Play' modems and prompting you through the necessary software and device driver installation. Most problems are the result of resource conflicts. Check the Device Manager to see if a conflict exists, and for suggestions on what you may need to do to resolve it.

Part III

Making the Connection

F-22 ADF and Total Air War offer four different connect options: IPX for network play, TCP/IP for Internet play, Modem for direct dial up play, and Serial for direct cable connection. All of these methods share the same basic interface and procedures. This section will cover these basics, pointing out specific differences for each as they apply.

Connection Basics

When you first select Multi-Player from the Main Menu screen, a screen will appear that allows you to choose the connection method you will be using. Once you have made your selection, a list of games in progress – if any – will appear, along with the names of available players. Buttons at the bottom of the screen allow you to either create a new game or join one that someone else has already created. A chat window is provided which enables you to communicate any special arrangements you might wish to make with other players before jumping into the cockpit.

In general, the best performance will be obtained if the player with the fastest machine takes on the role of 'host' – that is, presses the 'New' button to create a game. Once a game is created, the host selects between the various scenario options available.The original F-22 ADF release offers only 'Head-2-Head' multi-player options. F-22 Total Air War offers the option of additional 'Co-op' or 'Custom Combat' multi-player scenarios by pressing the appropriate button in the upper left-hand corner of the screen. There are nine different 'Head-2-Head' scenarios, allowing competitive 'free for all' or team-based play for up to 8 players. Total Air War adds ten additional 'Co-op' mission scenarios as well as the opportunity to create an almost limitless number of 'Custom Combat' scenarios As other players enter the multi-player screen, their names will appear in the current player list. 'Lurking' players are those who have not yet joined a game. Highlighting one of the available 'Games in Progress' items will display details about the host and chosen scenario. Pressing 'Join' to enter one of the games changes a player's status from 'Lurking' to 'Interface'.

Depending on the scenario chosen, players may or may not have the option of selecting weapons and/or team affiliations. If applicable, the current player list will display an F-22 icon in the selected team colour. A red 'X' alongside a player's name indicates that he/she has not yet made their final choices. Once you are satisfied with weapons and team selections, press 'OK'. The red 'X' will change to a green check mark.

The game will start once all players have pressed 'OK'. In order to better coordinate when game play begins, the host should be the last player to press 'OK'. Prior to starting a scenario, the host may 'Reject' a player, returning him or her to the 'Games in Progress' list.

Players may enter 'Head-2-Head' games at any time, even after it has begun and may leave at any time without ending the game for everyone else. If the host leaves the game, the next player on the list becomes the host. Cooperative and custom mission scenarios can only be joined at the start of a game.

Games end when either all players leave, the timer runs out, or one player (or team) scores enough points to obtain a victory. The specific 'end game' conditions vary from one scenario to the next and will be covered in more detail in a subsequent section.

Network Connections

Ethernet network connections are the fastest and easiest to establish. As soon as you select 'IPX', you should see and be seen by all other players in the game. If any players are not visible, verify that Windows networking has been correctly set up. For best performance, the player with the fastest machine should take on the host role by pressing the 'Create' button.

Since network players are generally all in the same room, coordinating scenario decisions is a simple matter. This arrangement is ideal for 'Co-op' scenarios where communication is crucial to mission success. However, few things are more fun than hearing your opponents scream as you shoot them down in competitive 'Head-2-Head' scenarios!

Internet Connections

If you do not have access to a group of local network players, you can still play F-22 ADF and Total Air War with other players across the Internet. For the price of a local phone call and an account with a local Internet Service Provider (ISP), you can play with players from around the world.

Internet connections will not be as smooth as IPX Network connections due to the greatly reduced speed at which the data is

transmitted. It is not uncommon to experience warping across these connections. Factors such as modem and ISP speeds, Internet traffic levels, or the number of servers your signal must pass through all contribute to the problem. As a consequence, the best performance is generally obtained when the player with the fastest connection to the Internet serves as the host.

Before loading F-22 ADF, establish a TCP/IP connection to the Internet using Windows' Dial-Up Networking. You will want to make note of your 'IP Address' - expressed as four sets of numbers separated by periods – if you intend to serve as the host. You can determine your 'IP Address' by running WINIPCFG.EXE, located in your C:\WINDOWS sub-directory.

Once F-22 ADF is running, select 'Internet TCP/IP Connection for Direct Play'. There are no significant differences between hosting a game across an IPX network or hosting one on the Internet. Simply press 'Create' to start hosting a game and selecting scenario options as outlined above.

In order to join a game across a TCP/IP connection, you will need to know the 'IP address' of the host. When you select 'Join', a box will appear where you can enter the host's IP address. Press the 'Enter' key to establish a connection.

Since players are usually located at some distance from each other, you will have to make arrangements to find opponents and exchange host IP address numbers. A variety of options exist on the Internet for meeting and chatting with other players such as: ICQ, Instant Messenger, Kali, Kahn, Internet Relay Chats (IRC), Powwow, Microsoft Net Meeting, real time forums such as DiD's own Internet site, and others. Among these, ICQ, Instant Messenger, Kali and Kahn offer the most effective means of finding opponents.

ICQ (from Mirabilis Ltd. at www.mirabilis.com) and Instant Messenger (from America Online at www.aol.com/aim) are free services that allow you to 'see' whether your friends are currently logged on to the Internet, chat with them or leave messages in order to arrange times to meet. In addition, you can search the member database for others who have expressed an interest in F-22 or other multi-player games. Once you have established your 'buddy list', it is a simple matter to see who is online, exchange IP addresses and start up a game.

Kali and Kahn are programs that allow you to simulate an IPX network connection using the Internet as the 'cabling' rather than physical wires. We will cover how to obtain and use Kali and Kahn in more detail later on, for now, we are interested in a different feature provided by these programs, namely the ability to locate and chat with other F-22 ADF players. Both Kali and Kahn operate through

dedicated servers scattered throughout the Internet world. When you log on to one of these servers, you have the capability of chatting with other users in order to exchange IP addresses. Kali offers an additional feature which makes locating players even easier, that is the ability to create private 'game room' that can be seen by others. By naming your room 'F-22 ADF' or something similar, other players can find you easily without having to blindly search through a myriad of servers. Once players are together in a room, they can chat with each other, exchange addresses, choose game play parameters, etc..

Whichever method you use to find and communicate with each other, decide which of you will act as the host for the game. Everyone else will need to make note of the host's IP address. At this point, exit from whatever program you are using to chat and fire up F-22 ADF. Of course, do not disconnect from the Internet!

If you are acting as the host, the procedures you will follow are identical to those described in the network section above except that you will select 'Internet TCP/IP' as the connection method rather than IPX. Create a new game and wait until the other players appear in the 'Current Players' window.

If you are joining the game, choose 'Internet TCP/IP' as your connection method, then press the 'Join' button. A window will appear asking you to enter the host's IP address. This will be a set of four numbers separated by periods. Once the connection is made, you will be able to see the host's game in the 'Games In Progress' window and the other players in the 'Current Players' window. Highlight the host's game and select 'Join'. From here on out, the process is identical to the one described in the network section above.

In theory, up to eight players can participate in the same head-to-head scenario, and up to four players in the same cooperative or custom mission at once. However, because Internet connections are very much slower than those obtained on a network, this is not recommended. The more players you have, the more data must be exchanged across the connection. As the amount of data exceeds the capacity of the connection more and more, warping will get worse and worse. Using 28.8K or 33.6K modems, some warping may be seen even with only two players. If everyone is using 56K modems, you might be able to connect three or four players without excessive warping. Cable modem connections everyone? Call on four or five of your lucky buddies to join you!

The above numbers apply to head-to-head scenarios. Cooperative and custom missions demand a great deal more data transfer between players and consequently may exhibit warping at lower numbers of players. Because of the unpredictable nature of the Internet, the quality of your gaming connection may vary from one session to the next, or even from moment to moment. As noted previously, there are

many factors that can affect how well you can connect to a remote player such as ISP speed, overall Internet traffic, etc.. If you are plagued with excessive warping, even on two player connections, there are things you can do to try and improve the situation. Some are easy, such as hooking up to the Internet at off-peak hours or playing with folks who are geographically closer to you (fewer Internet hops). If there are several providers in your area, you might try a different ISP to see if their connections are any better. Ultimately, performance boils down to your connection speed. Improving it may involve spending money on a faster modem, ISDN or cable connection, etc..

Modem Connections

Direct modem connections in F-22 ADF deliver excellent results and generally exhibit less warping than Internet connections. Unfortunately, direct modem connections are limited to only two players at a time. In addition, unless the players live close to each other, long distance charges will quickly become excessive. If you are fortunate enough to have local players available in your calling area, direct modem connections are an effective and inexpensive option you should consider.

The player serving as the host will receive the call. Select 'Modem for Direct Play' and press the 'Create' button. Windows95 will bring up a modem control screen and set up your modem to answer automatically. The player placing the call should select 'Join' and enter the phone number in the modem control screen. Once the connection is established, the host chooses and initiates the scenario in the same manner as outlined for Internet and Network connections above.

Serial Connections

The cheapest way to connect two computers together for F-22 ADF play is to use a direct serial connection. The only hardware required is an inexpensive 'Null Modem' cable and an open serial port on both computers. Both computers must be in close proximity. However, as with IPX network connections, this is ideal for co-operative play.

Game performance is generally better than that provided by a direct modem connection, but not as good as a network connection. The limiting factor is the speed of the serial ports on the two systems. Most Pentium class machines have serial ports capable of reliably sending and receiving data at 57.6 Kbps. For optimal performance, the fastest system should take on the role of host. Choose the 'Serial for Direct Play' option. Press the 'Create' button if you are the host, otherwise, press the 'Join' button. Each player will be presented with a Windows95 serial port setting window. The default setting of 57600

baud, 1 stop bit, no parity and RTS/DTR data flow work well in most cases. Select the communications port to which you have attached the null modem cable and you should be able to see each other in the 'Current Players' window. Except for the selected port, both systems should use identical communications parameters.

Windows95 provides serial port communications support at speeds up to 115,200 baud. It is worthwhile to experiment with this setting - the faster the connection, the smoother the game play will be. However, not all serial ports are able to support this speed reliably. If you experience broken connections or other problems, try reducing the baud rate back to 57600, or even lower in extreme cases.

Since you cannot connect two devices on the same serial port, it may be necessary to modify your modem settings (if you have a modem installed) so that it does not conflict with the selected serial port. For older modems, this may require that you remove your modem and adjust jumper settings. If you have a 'Plug and Play' modem, or one that uses software to select communications port settings, you should be able effect the necessary changes without opening up your computer. Follow the instructions in your modem's manual as to the necessary procedures. As always when you are making changes to your system, take careful note of existing settings so that you can restore them if things do not work as anticipated.

Kali and Kahn Connections

As noted previously, Kali and Kahn are programs that use software to simulate an IPX network connection across the Internet. By connecting to a Kali or Kahn server, players can chat and hook up directly, alleviating the need to enter IP addresses for the host machine. Prior to the advent of direct Internet connection through TCP/IP, Kali and Kahn offered one of the only alternatives for players to connect across long distances without making costly phone calls. For a low ($15-$20) one time fee, players are free to use Kali or Kahn servers as often and for as long as they please. However, since F-22 ADF and Total Air War offer a direct Internet option, Kali and Kahn are less attractive than they might otherwise be.

Game performance while using Kali or Kahn may not be as smooth as a direct Internet connection if all players have fast connections. However, in situations where players have only moderate connections, performance is comparable to a direct connection, and may actually be better in some cases. There are simply too many variables to be able to predict what your experience will be. The best suggestion is to experiment and find out. Fortunately, both Kali and Kahn offer free trial periods for their software. You can obtain a copy of Kali at www.kali.net. Kahn is available from www.stargatenetworks.com.

Kali offers a better user interface, while Kahn's software employs a compression routine that reduces the amount of data transferred across the Internet connection. As a result, you may find Kahn to be slightly smoother than Kali. Once again, this is something that you will have to experiment with to determine whether your connections with Kahn are improved over those with Kali, or over a direct Internet connection.

DiD has released a communications 'patch' for F-22 ADF that includes fixes which improve performance over Kali and Kahn.

To connect through Kali or Kahn, you must first establish a connection to the Internet, then run the appropriate software that will connect you to one of the remote servers. Both programs allow you to gauge the speed of remote servers by observing what your 'ping' times are. Ping times refer to the time it takes a signal to travel from your machine to a server and back. The lower the ping time, the speedier the connection will be and the less you will be bothered by warping or lost connections. You will want to try to use connections offering ping times of 500 or less.

When you and your fellow players are connected to a server, you will be able to use a chat window to discuss scenario preferences, decide who will host the game, etc.. As with direct Internet connections, the machine with the fastest connection (the lowest ping times) should take on the role of host for the smoothest game play. To start a game, simply leave Kali or Kahn running in the background, start up F-22 ADF and select the IPX connection option. Follow the procedures outlined in the network section above, and you will soon be in the air together.

The private 'game room' option offered by Kali allows you to start a game without requiring all players to gather together on one of the remote servers. Unfortunately, this feature does not appear to work for F-22 ADF as of this writing. Nonetheless, it does provide an easy way for players to find each other and chat to compare notes on ping times, server speeds, or to exchange IP addresses in order to establish a direct Internet connection. In the final analysis, this last application may be best use of these programs as opposed to using them as IPX emulators.

Part IV Multi-Player Gaming Scenarios

Both F-22 ADF and Total Air War offers nine different 'Head-2-Head' multi-player game scenarios in a variety of air-to-air and air-to-ground scenarios. In addition to the 'Head-2-Head' options, Total Air War adds ten 'Co-op' missions as well as the ability to create custom multi-player scenarios. Victory conditions vary depending on the mission chosen and can involve both air-to-air as well as air-to-ground objectives.

Head 2 Head Scenarios

Some Head-2-Head scenarios start with all players in the air, others with players on the ground at one or more airfields. Winners are determined by point totals scored during the course of play. Some scenarios are 'free for all' situations where each player attempts to score the highest number of points. Others group players into one of four teams where each player's score contributes to the success or failure of his/her team. The mission briefings outline the objectives and victory conditions for each scenario. With one exception, all scenarios are timed, with game length ranging from 20 to 50 minutes.

All aircraft start with a full internal fuel load and 515 rounds of ammunition for the M61A2 20mm cannon. The availability of other weapons varies depending on the nature of the scenario. Where options exist, each player may individually select the weapons load out he or she is carrying, independent of any other players. Once selected, weapons load outs and team affiliations cannot be changed unless the player leaves the game and reenters. If a player leaves a scenario, his score is reset to zero upon reentry. The game ends whenever the last player leaves, time runs out or the victory conditions have been met.

A player's aircraft can be rearmed and refueled only in scenarios that include air-to-ground weapons, and then only where a friendly airfield is provided. Rearming and refueling is accomplished by landing at the friendly base. No rearming or refueling is performed at enemy bases in such cases where they exist, although points are awarded for successfully landing at an enemy base.

Players who are shot down or crash are reincarnated back into the game, either in the air or on the ground as is appropriate to the

scenario in play. Points cannot be scored against a recently reincarnated player until they have been airborne for approximately 5 seconds, giving them the opportunity to re-engage the battle. While in this 'protected' mode, a large 'X' appears over that aircraft's target designation visible in the HUD. Reincarnated players CAN inflict damage upon or even destroy any other aircraft immediately, even while in protected mode. So if you have been shot down, you have a brief window in which to take your revenge!

Points Scoring

A running total of your score is kept during the course of the game. Shooting down opposing planes and/or destroying enemy ground targets increases your score. Being shot down, crashing into the ground or destroying inappropriate ground targets decreases your score. If you are playing as part of a team, your score is added to (or subtracted from) the total for your team.

Action	Points
Shooting down an opponent	+ 4 points
Shooting down a team mate	- 5 points
Being shot down	- 1 point
Crashing into ground	- 6 points
Ejecting from aircraft	- 6 points
Destroying designated ground target (1)	+ 5 points
Destroying non-designated ground target (2)	- 10 points
Landing at an enemy base (3)	+ 20 points

(1). 'Designated' targets are any mission targets - buildings or structures – that have a triangular ground target icon superimposed over them when viewed through the HUD.

(2). 'Non-Designated' targets are any buildings or structures that do not have ground target icons associated with them.

(3). You must come to a complete stop on the enemy runway, engage the wheel brakes and turn off the engines in order to score points.

Whenever a player scores points, is killed, enters or leaves the game, a screen will briefly scroll up listing each player's total score as well as the number of kills and deaths he has tallied. In addition, if there are teams involved, a total team score will be presented. This screen can be displayed at any time by pausing the game with the P key.

When a scenario is completed, a tally board will appear listing the winning player or team, along with a grid outlining how many kills each player has scored against each other player. The number of

ground targets destroyed is shown if applicable. Finally, a summary of weapons effectiveness is also given showing hit ratios for the various weapons used in scenario.

Canyon Chaos Scenario

This scenario is a 'free for all' air battle fought in the skies over the Nubian Desert in northern Sudan, approximately 75 miles southeast of Abu Simbel, Egypt. It is mid-morning when the action begins. All players start in the air, armed only with their cannons. No refueling or rearming is available – use the 515 rounds of 20mm ammunition wisely! If you are killed, you will be reincarnated with full fuel and weapon loads near the original starting point.

Shooting down any of the other players scores points. Points are lost if you are shot down or crash into the ground. The game ends when the 20-minute time limit is reached or if a player wins by scoring 20 points. If no player scores 20 points before time runs out, the player with the highest score is declared the winner.

Seaside Slaughter

This scenario is also a 'free for all' battle. All players start airborne in midday skies just off the Yememi coast, about 50 miles south of Al Hudaydah. In addition to the default 515 cannon rounds, players can choose to add a pair of AIM-9X Sidewinder missiles, carried internally, to their weapons load out. As in the 'Canyon Chaos' scenario, no rearming or refueling is provided.

This scenario ends either when a player wins by scoring 50 points, or when the 50-minute time limit is reached. If no player scores 50 points before time runs out, the player with the highest score is declared the winner. Players who are killed during the course of the fight are reincarnated near the original starting point.

Mountain Madness

All players start in the air over the rugged terrain along the Saudi Arabian and Yememi border. This is a 'guns only' scenario, but the darkness of the desert night makes this doubly challenging. Unlike the previous two scenarios, players compete as members of one of four teams: red, blue, green or yellow. Allegiance is indicated by the colour of the 'name' appearing beneath each target's icon in the HUD and HMD views. Take care to avoid shooting down your teammates!

Points are scored by shooting down players flying for opposing teams and are kept on an individual, as well as a team basis. The game ends either when time runs out – after 30 minutes – or when one team wins by scoring a combined total of 40 points. If no team has scored 40

points before time runs out, the team with the highest score is declared the winner. No refueling or rearming is provided. Make every shot count! If you are killed, you will be reincarnated with full fuel and weapon loads near the original starting point.

Forest Fight

This is another 'free for all' scenario fought with 'guns only'. Unlike the previous scenarios however, all players start on the ground at the Lalibela airbase in northern Ethiopia, about 100 miles east of Gonder. The battle takes place over hilly, forested terrain and begins around sunset.

The winning player is either the first to score 40 points or the player with the highest score once the 50-minute time limit is reached. Players who are shot down during the game are reincarnated on the runway at Lalibela. Despite the presence of Lalibela airbase, no rearming, refueling or repairs are provided if you land, so once again, use your ammunition wisely.

River Battle

This battle takes place over the outlet of Lake Tana, which flows south to join with the Blue Nile. This is a team scenario, and players can select to join one of the four teams available. The battle begins at sunset, with all players starting on the ground at Bahir Dar, an Ethiopian airbase along the southern shore of Lake Tana, about 75 miles south of Gonder. In addition to your 515 cannon rounds, you may choose to arm your plane with a pair of internally carried AIM-9X Sidewinder missiles. As with the 'Forest Fight' scenario, no rearming or refueling is provided, even if you land successfully at the airbase.

This scenario ends automatically either after 30 minutes, or when one team has scored 40 points. If you are shot down, you will be reincarnated on the runway at Bahir Dar with a full load of fuel and weapons.

Battle For The Isle

Dawn over the islands at the southern end of the Red Sea off the Yemeni coast is the setting for the final air-to-air only scenario. All players in this team based game start out on the ground at the Barim Island airbase. Radar guided missiles are available for the first time. You may choose from three different weapons load out configurations: 515 rounds of 20mm cannon shells only, cannons plus a pair of AIM-9X Sidewinder missiles, or a full complement of guns, sidewinders and four AIM-120C AMRAAM missiles. The AIM-9X missiles are carried internally; the AIM-120s are loaded externally,

under the wings. Although you are packing a bigger punch, you will still need to shepherd your resources carefully since no rearming or refueling is available.

This scenario lasts for 40 minutes or until one team scores 50 points. If you are killed, you will be reincarnated, fully loaded, on the runway at Barim Island.

Battle For Lahij

This is the first of three air-to-ground scenarios provided. Lahij is a small city about 25 miles west of Aden in Southern Yemen. The scenario is not so much a battle 'for' Lahij as it is bombing contest to see who can destroy the most buildings in the shortest amount of time. Players join one of two teams: the red team starts on the ground at Al Anab airbase, the blue team on the ground at Al Ittihad. These airbases are about five miles apart, flanking the city of Lahij on roughly opposite sides. Your home airbase is located at waypoint number 1, the city of Lahij is located at waypoint number 2.

The object of the game is to see which team can destroy the most targets while preventing the opposing team from doing the same. Points are awarded both for destroying buildings as well as shooting down opposing aircraft. Do not destroy any targets outside the central city, as points will be deducted from your team's score for doing so. Only buildings that have triangular target icons superimposed over them when viewed through the HUD or HMD are valid targets. Points are also awarded for landing on the opposing team's airbase. To score, you must come to a complete halt on the runway, engage your wheel brakes, and shut down your engines.

Your aircraft will carry both air-to-air and air-to-ground weapons. The air-to-air load out consists of a full magazine of 20mm ammunition as well as a pair of AIM-9X Sidewinder missiles. You have a choice of air-to-ground ammunition: 120 LAU-68 rockets, carried on external pods, 12 AGM-65G Maverick missiles, also carried externally, or 14 Mk 83 free fall bombs, a half-dozen carried under each wing and a pair in the internal bomb bay. Rearming and refueling is available only at your home airbase, however no battle damage repairs are provided. As with scoring points for landing on the opposing team's runways, you must come to a complete stop on the runway, set the wheel brakes and shut down the engines in order to rearm and refuel. The process is nearly instantaneous. Once you confirm that you are rearmed and refueled, take off and rejoin the battle.

No time limit imposed in this scenario. The winning team is the one with the most points after all available targets have been destroyed.

Mountain Battle

Mid-afternoon in the mountains of southern Saudi Arabia, about 100 miles south of Jizan, is the setting for this next air-to-ground scenario. Once again, two teams battle for superiority. This time however, the target is each other's airbase. The red team starts out at Abha, the blue at Khamis Mushayt, a pair of bases about 25 miles apart. Your base is located at waypoint number 1, the enemy base is located at waypoint number 2.

Your choice of air-to-ground weapons is the same as in the previous scenario, the 'Battle for Lahij'. Air-to-air weapons, cannons and Sidewinder missiles, are also provided to allow you to provide a CAP over your base and deny the enemy the opportunity to destroy his designated targets. Rearming and refueling is provided when you land at your home airbase. As above, points are awarded for destroying designated targets, landing on the enemy's base, or shooting down enemy planes.

The scenario will run for up to 40 minutes or until all targets are destroyed at one of the airbases. The team with the most points at the end of the game wins.

Base Attack

The final air-to-ground scenario is a night mission over the straits at the southern end of the Red Sea. Four teams compete, flying from four different bases. The red team starts on Barim Island in southern Yemen. The other teams start at bases in Djibouti, about 50 miles north of the capital: the blue team launches from Tadjourah, the green team from Fagal, and the yellow team from Obock. Note that this is NOT the starting positions listed in the mission briefing. Barim Island is about 20 miles northeast of Fagal, which is about 25 miles north of Obock, which in turn is about 20 northeast of Tadjourah.

Waypoint routes for this scenario are not intuitive, as they do not place a waypoint marker at each enemy airbase. In all cases, your home airbase is located at waypoint number 1. This is useful for finding your way back to the proper airbase amidst the many which are in the area. If you choose to play on the red team, your navigation system will place waypoint number 2 at Tadjourah. Green and yellow will also find that Tadjourah is located at waypoint number 2. Finally, blue will find Barim Island under waypoint number 2. To locate other bases, you will have to rely on the map display in TSD.

Load outs for air-to-air weapons and choices for air-to-ground weapons are the same as in the previous scenarios. Additionally, rearming and refueling services are provided at your home airbase.

Points are awarded for destroying ground targets at enemy bases, landing at enemy bases, as well as for shooting down enemy planes.

This scenario is set to run for 40 minutes or until one team scores 100 points.

Tactics For Air-To-Air Scenarios

When playing 'free for all' scenarios, it is very much every man for himself. The best tactics may strike you as mercenary or unfair, but the object is to score as many points as possible. As a result, you must take the attitude that 'all's fair' or you will not win many encounters. Of course, if you employ all of these regularly you will not make many friends either, but that's war!

In scenarios where players start on the ground, attacking a player who has just taken off is extremely effective. Swoop down on the airbase and line up on your opponent's six as he becomes airborne. The protected status period during which you do not receive any points for a kill is relatively short. Simply hold your position, and your fire, until the 'X' disappears, shoot, and then quickly loop around to line up again.

Another effective technique is to attack players who are attacking someone else. While your opponent is fixated on his own target, you can often sneak in undetected and obtain an easy kill. As icing on the cake, once you dispatch the attacker, you should be in good position to take up the attack on his original target yourself. If you are especially lucky, this second target may already be damaged and even easier to kill.

If you are worried that these tactics will give you an unfair advantage, rest assured that your opponents will soon gang up on you in retaliation!

In team play scenarios, work together with your teammate and try to cover for each other as much as possible. Co-operation is vital to the success of the team. Avoid pursuing targets when the odds are weighted in their favour. If your teammate has been shot down, it is often better to make a run for your base. This will draw the enemies towards your teammate who will now be entering the fight with a full complement of air-to-air weapons.

Since no rearming or refueling is available in air-to-air scenarios, when you have expended all your weapons you have no choice but to die in order to be reincarnated in a fresh airplane. Similarly, if you are damaged, you also need to die in order to get a new airplane. Whenever possible, avoid crashing or ejecting. These actions have the most negative impact on your score - subtracting 6 points. Being shot down by a teammate is better for you as you only lose 1 point. However, it is no better for the team overall since your teammate is

docked 5 points - a total of negative 6 points again. Being shot down by an enemy costs you only 1 point, but earns your opponent (or his team) 4 points. On the surface, this may seem preferable since it nets only 5 points to the enemy versus 6, however you will need to pay attention to their total score. Some games are won when one team has achieved a certain point goal. Granted, negative points do not help you reach that goal, but they do not help your opponent reach it either.

In 'free for all' scenarios, no team scoring applies. Points are either awarded to who shoots you down, or subtracted from your score. There are situations where it may be better to crash than to be shot down. For example, if you are badly damaged and wish to deny other players of the points for – and pleasure of – killing you. Of course, if you make a habit of ejecting at the first sign of enemy fire, not only will you not win any games, but you will also anger your opponents. Beating you by 30 or 40 points is not going to be very satisfying for your opponent if the score is MINUS 30 or 40 to nothing.

Tactics For Air-To-Ground Scenarios

All of the air-to-ground scenarios in F-22 ADF are team oriented, and, except for the 'Battle for Lahij' scenario, are similar to the base defence option in DID's earlier release, EF2000. The object is to land at or destroy your opponent's airbase. Consequently it is a very good idea to always be sure that at least one player takes on a CAP role in order to prevent the enemy from striking, or worse yet, landing at your own airbase.

One effective technique is to have the aircraft assigned to the strike package linger over the enemy base as long as possible, striking as many targets as possible. When that plane is near destruction, the CAP player heads out to take its place, allowing the soon-to-be reincarnated player to guard home plate with a full complement of air-to-air weapons. Although you will lose points by allowing yourself to be shot down, you will gain far more points overall if you can destroy several ground targets. At the same time, you deny your opponents the opportunity to do significant damage to your base by always maintaining a fully armed CAP.

The CAP aircraft should pay close attention to the actions of the strike aircraft and avoid killing enemy planes at inopportune times. For example, if your teammate is about to land at the enemy base, killing an enemy plane will result in a freshly reincarnated enemy right on the runway!

Do not forget that landing on the enemy's base is worth a lot of points. This is not easy to do however, since you will have to fly a very predictable path at low speed – a ripe target for enemy CAP aircraft. Unless the base is unprotected, you will have your work cut out for

you. Keep your landing approaches short and fast. Remember that you will need to come to a complete halt on the runway with your engines off and the wheel brakes on. Shut down your engines and hit the brakes as soon as you make contact with the runway. Doing so will make your landing roll as short as possible. Having a teammate occupy the CAP while you sneak in at low altitude is an excellent technique as well!

Your choice of air-to-ground weapons will have a profound effect on what tactics you should employ. Rockets allow you to strike numerically more targets in a shorter period of time due to the large number of shots available. Your attack pattern is lower and slower than is required for a Maverick missile or Mk 83 bomb attack, allowing you to shift your aim more easily. However, you also make an attractive target of yourself in the process. Bombs allow you to make high speed, diving attack runs, reducing your vulnerability to enemy gunnery. Unfortunately, this limits the number of targets you can line up on.

The tactics you will use when striking a target depend heavily on which weapon you decide to carry. Bombs allow you to attack from high altitude while diving at high speed. This approach makes it much harder for enemy CAP planes to shoot you down with guns. Rockets require a lower and slower attack run than that required by bombs, leaving you more vulnerable. However, you can strike a lot of targets with 120 rockets on board! In addition, rockets are excellent against newly reincarnated planes as they head down the runway. You will not score points - protected status - but you may buy yourself enough time to hit a couple more ground targets before the enemy reincarnates again. Maverick missiles are the least useful weapons to carry. Unlike rockets or bombs, Mavericks are impossible to aim quickly, or easily.

Part IV CO-OP Mission Scenarios

Ten co-operative multi-player missions have been included in the F-22 Total Air War release. Mission objectives include a variety of ground strike, support and air combat scenarios. The mission briefings provide complete information on targets and objectives. Missions vary from fairly short (45 minutes or so) air defence 'scramble' style missions, to lengthy (several hours in duration) strike missions complete with aerial refueling.

Weapons load outs and waypoint routes are pre-assigned based on the mission goals. Rearming and refueling is possible if you land at a friendly air base and come to a complete stop on the runway. Waypoints may be edited while in the mission using the waypoint editor on the Tactical Systems Display (TSD).

The host will assume the role of flight leader. Other players take the role of wingmen, up to a limit of 8 players per mission. If less than 8 players participate, computer wingmen will round out the flight. If a player is killed during a mission, the mission must be aborted and re-started before he or she can re-enter the game.

The following provides a brief synopsis of each mission.

Scud Busters

Although the description lists the starting location as Saudi Arabia, the briefing map correctly shows your take-off location as Dunqulah dispersal airfield in northern Sudan. Your objective is to search for and destroy at least seven SS-23 Scud Missile launchers, located in four areas just north and south of the Sudanese and Egyptian border. Although of only moderate length, you will spend a lot of time at low altitudes during this mission. A refueling plane is available about two-thirds of the way through your waypoint route should you feel thirsty.

Each F-22 in the flight is loaded with four Mk 20 free-fall bombs and two AGM-88 HARM missiles for SAM defence. Two AIM-9X Infra-Red and two AIM-120C Radar Guided missiles provide A2A defensive coverage. A full load of M61A2 20mm cannon shells, 1750

rounds, is also loaded and can be used either to strafe ground targets, or against enemy fighters.

Once all the scuds are destroyed, return to Dunqulah dispersal and land safely to end the mission.

Egyptian Strike

You begin this strike on the runway at Yanbu al Bahr airbase in southern Saudi Arabia, ready for take off. Your objective is to fly west across the Red Sea, and use laser-guided GBU-24 bombs to execute a surgical strike against the Egyptian Air Defence Headquarters.

Four, very specific targets must be destroyed - two multi-story office buildings, a power station and a smokestack - while leaving the control tower and barracks building untouched. Return safely to Yanbu al Bahr in order to successfully complete the mission.

Egyptian air defences are expected to be on high alert, so each F-22 is loaded with two AIM-9X, two AIM-120C, two AIM-120R missiles as well as a full drum of 20mm cannon shells for air defence.

Since you will be over enemy territory for most of this mission, rearming and refueling is, while not impossible, impractical at best. Use stealth to mask your approach and make your missile attacks count when the fur starts flying!

Escort Allies

This CAP mission begins in the air over southern Eritrea. Your mission is to provide escort and air cover for an arriving flight of British Eurofighters. Ethiopian interceptors will try to shoot down the ferry flight, while bombers try to destroy the Eritrean airbase the Eurofighters will be operating out of.

To succeed, you must protect the Eurofighters, AND prevent an attack on the airbase. Once the Eurofighters have landed, you must fly northwest and land safely at your own base, Akordat dispersal field in central Eritrea.

Your flight of F-22s is loaded for bandits, each carrying two AIM-9X missiles, two AIM-120R, long range radar missiles, and six AIM-120C medium range missiles. Rearming and refueling is possible by landing at any friendly base within Eritrea. Practice your battlefield approaches for this one because you may need to reload quickly.

Airfield Denial

It is early morning, and you are ready to take off on a strike mission from the Dalol airbase in Eritrea. Your flight is part of a large strike force of F-22s and F-15Es tasked with shutting down four airfields in

Ethiopia. Your flight must destroy three hangars as well as the control tower at one of the Ethiopian bases, then return safely to Dalol.

You will be carrying a heavy Air-to-Ground load consisting of six Mk 83 free fall bombs and six AGM-65G Maverick missiles. SAM and AAA protection around the Ethiopian bases is heavy, and you cannot count on your SEAD (Suppression of Enemy Air Defences) flights to knock out all of them. Plan on taking out the remaining SAM and AAA sites from 'stand off' range with your Mavericks before you hit the bases with the heavy iron. You will also need to be alert for Ethiopian interceptors that will scramble from the target bases. Your air defence load-out of two AIM-9X, two AIM-120R and four AIM-120C missiles should be enough to keep you out of serious trouble, however – of course, you never know!

Rescue CAP

While executing early morning raids over Ethiopia, an F-15E was been shot down before the crew could cross over into friendly airspace over Eritrea. Although the pilot and weapons systems officer were able to bail out, their emergency beacons have alerted Ethiopian who are rapidly converging on the downed crews position. It is now mid-morning and your mission is to provide escort and air cover for the rescue teams.

You start parked in a revetment at Jizan Airbase in southern Saudi Arabia. The helicopters and A-10 ground support aircraft are just taking off as the scenario starts, and soon you will receive clearance to take off and join them for the flight across the Red Sea. Your F-22 is loaded with a variety of weapons to facilitate your role as air cover and SEAD for the rescue teams. Eight AIM-120s, four each of the 'C' and 'R' models, and a pair of AIM-9Xs make up the air-to-air missiles. Six AGM-65G Maverick missiles and thirty LAU-68 rockets round out the air-to-ground kit. You'll need all that, as there will be a lot of enemy activity. The pair of MiG-21s you are expected to kill should present no problems, the Su-27s may be a bit more challenging. You'll have to deal with the airborne threats while you are knocking out the mobile AAA and SAMs hoping to bring some more aircrews down to the party in the sands.

Once the pickup is made, it will be up to you to watch everyone's backs as you make your way back to Jizan, where, as tradition has it, the thankful crews will buy everyone a round of cold ones.

Naval Strike

It is early afternoon on a beautiful day at Dikhil dispersal field in Djibouti. A lovely day to go fishing – for BIG fish! You are tasked with

enforcing the UN Security Council's control zone in the Gulf of Aden, south of Yemen. The Yemeni forces have been building up air and naval forces in preparation for a push against the blockade. You have been authorised to use deadly force against any ships trying to enter the zone. Expect heavy Yemeni air activity over the Gulf as they test the boundaries of the control zone. When the ship movements begin, they will no doubt try to draw you away from the action on the water.

You will be carrying four AGM-84A Harpoon anti-ship missiles and two AGM-65G Maverick missiles, 'just in case'. You will need to coordinate any offensive actions with your wingmen as the mission calls for 9 ships, of varying types, to be destroyed before the day is through. To ward off any fighters who want to play you have two AIM-120Cs and two AIM-9X Sidewinders aboard. Make the best of all your shots because it is a long way back to Djibouti for resupply. Complete your patrol, then return to base. Just don't expect the commander to believe your stories about 'the one that got away!'

Air Force

The brass wants your squadron to provide SEAD for the Saudi F-15Es during this nighttime strike on Yemeni airbases just across the border from Saudi Arabia. The darkness is not going to make your job ANY easier. Enemy SAM, AAA and air activity has been high all day and there is no reason to assume it will be any less so tonight.

Your F-22 is on the flight line at Ash Sharawrah airbase, loaded with four AGM-88 HARMs (High-Speed Anti-Radiation Missiles). Use them against the SA-11 SAMs and ZSU-23 AAA units waiting to spoil the show. Although you are carrying six AIM-120Cs and two AIM-9X Sidewinders, you will have to place your shots carefully and coordinate with your wingmen to bag the thirteen air-to-air kills you are tasked to complete in order to keep the bad guys off the F-15Es. Survive the night and return to base to complete this mission.

Scramble

Don't you hate rude awakenings? A huge flight of Yemeni fighters and bombers has overwhelmed Saudi CAP flights and is converging on Ash Sharawrah airbase – YOUR airbase. Dawn is just a few minutes away, but you are on the runway, ready to take off in the first wave of defenders. A quick glance at your MFDs reveals almost nothing but bad guys just minutes away. You say a quick word of thanks to the ground crews for the full load of air-to-air missiles on board – six AIM-9Xs and ten AIM-120Cs – then hit the burners and take to the skies.

You are expected to bring down nine Su-30s before the engagement is over, but you will have to fight your way through a horde of other enemy fighters to reach those targets. You should never stray too far away from the base, so remember that you can land to rearm and refuel as needed.

Morning Raid

Your F-22 waits in a hardened revetment at Bisha airbase in the cold desert dawn of southern Saudi Arabia. Rebel Saudi forces have taken over air and naval bases along the Yemeni border in support of enemy efforts to launch a major offensive – or at least, that is what the Intelligence officers tell you.

Your job is to assist regular Saudi forces in removing the rebels. All aircraft, either parked or in the air are fair game, as is a laundry list of other targets including ships and armoured units. You will have twelve AGM-65G Maverick missiles on board, allowing you to hit your targets and suppress most of the SAM and AAA threats from stand off range. A pair of AIM-9X Sidewinders and six AIM-120Cs should keep the interceptors that manage to get off the ground at bay. Despite all those Mavericks, you had better been practicing your strafing techniques before heading off on this mission. Work with your wingmen to mop up this target rich environment. Once the rebels have been driven back, head for home back at Bisha.

Strike San'a

The last of the cooperative missions is also the longest. You will be taking off from old Jiddah airport, on the Red Sea coast of central Saudi Arabia, on a mission to the heart of Yemen, the capital city San'a. Your middle of the night SEAD mission is intended to cripple the air defences surrounding key command and communications facilities – targets of the coming day's strike flights.

The SAM and AAA activity is VERY high. The sky will be lit up like the Fourth of July once the Yemeni forces pick you up. All you are carrying is a pair of AGM-88 HARMS and six AGM-65G Mavericks. Make every shot count and coordinate closely with your wingmen or you will find yourself out of weapons with a swarm of angry missiles in the air. A pair of AIM-9Xs and six AIM-120Cs should be enough to keep the interceptors at bay – for a little while at least.

This is an extremely long flight. A tanker waits for you over the Saudi desert as you head inbound. Be sure to fill up as your best chance of success is to try and sneak in – fast and low – a tactic that will burn up fuel in a hurry. Once you complete your strikes, head north along the coast where another tanker will be waiting to top off your empty tanks with gas to get you to your destination, Khamis Mushayt airbase.

Part V Suggestions for Play

You will probably use the multi-player scenarios for both fun and competitive play. In the latter case, it is worth considering applying some rules in order to make the experience more organised and more rewarding. In the 'free for all' scenarios, rules may seem counter to the opportunistic settings, however you may wish to establish some guidelines to reduce the number of 'mercenary' kills. For example, establishing an engagement area away from the starting point.

Another way to establish Rules Of Engagement (ROE) may be to limit the type of weapons that can be used. Missiles can be extremely, perhaps even unrealistically deadly in multi-player encounters. This is especially true when they are fired head on and from very short range. Limiting play to 'guns only' is one way to ensure that play revolves around close range dogfighting rather than 'in your face' missile kills.

If you are keen to demonstrate your prowess in air-to-air combat, there are many local or Internet based competitions that you can join. The most common formats for these are 'ladder' competitions. Ladders operate by arranging players in a vertical ranking. Newcomers enter at the bottom of the ladder and climb to the top by defeating more highly ranked players. ROE varies from one competition to the next, but the most common centre around one of two formats: 'Clean Pass', or 'Anything Goes'.

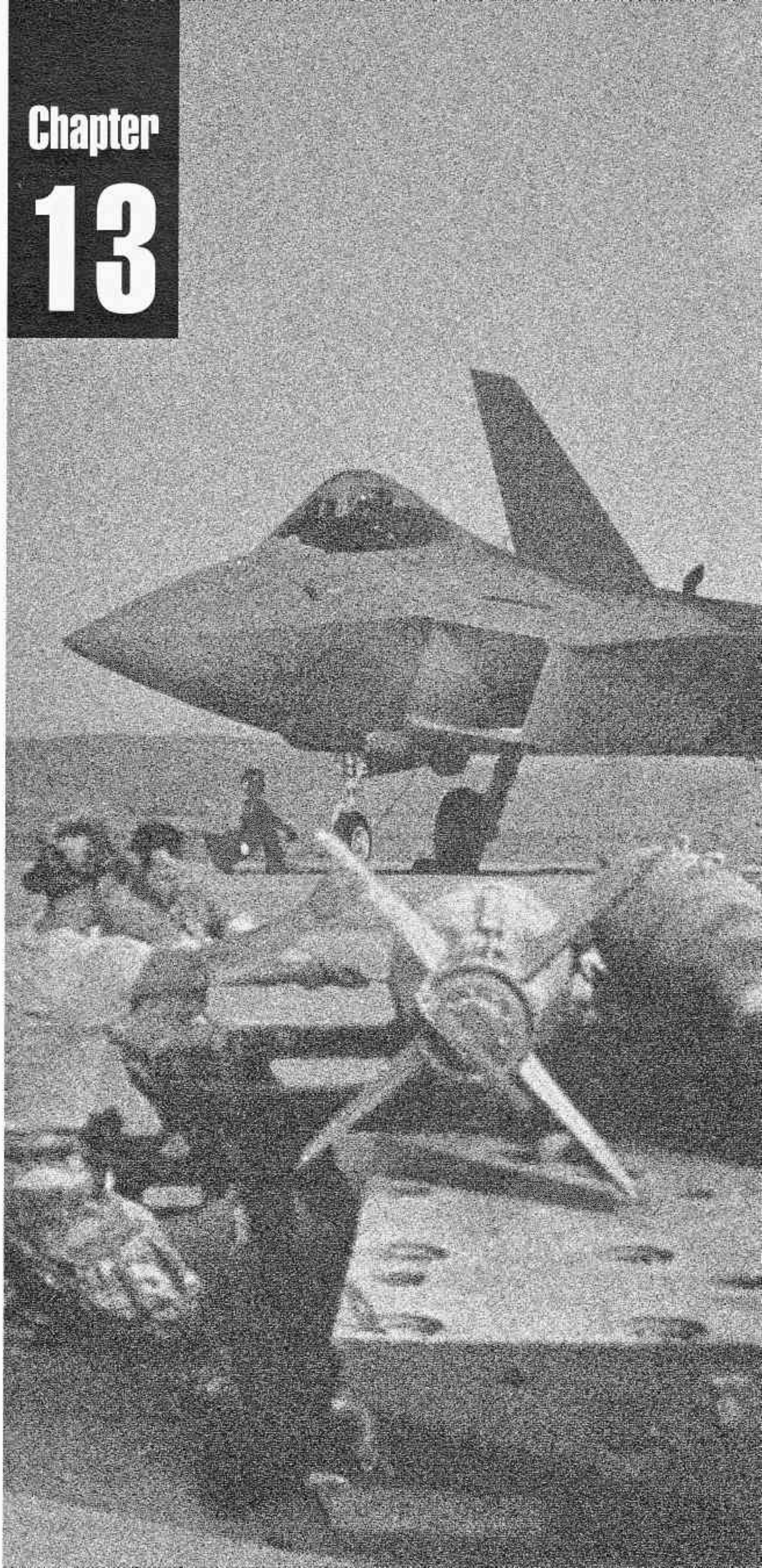
'Clean Pass', or as it is also known, 'Turn and Burn' (TNB) competitions begin with players at the same altitude some distance apart. The players then fly towards one another, passing closely without firing before hostilities begin. Once the planes have passed, the object is to turn into each other as quickly as possible and prosecute your attack, hence the TNB title. Variations on starting altitude and allowable weapons choices are common.

'Anything Goes', or 'ATG', does not require players to pass each other cleanly, instead, the fight is on as soon as they are in weapons range. Most frequently, an initial exchange of missiles occurs followed by close range dogfighting if the missiles fail to score a kill.

Regardless of the ROE, each encounter typically begins with both players in fresh, fully loaded and undamaged aircraft. Although

F22-ADF allows players to continue flying if their opponent is killed, this may result in an unbalanced fight with regard to fuel, weapons, or damage status. As a result, the winner of any given round will usually eject or crash in order to reset his plane to the default starting conditions. Obviously this makes point tracking an ineffective tool for determining overall winners and losers in a 'best of' however many rounds engagement. You will have to rely on the number of kills recorded against your opponent rather than on points or deaths.

Chapter 13



HARDWARE

GETTING STARTED

HARDWARE

FLIGHT CONTROLLERS

PATCH FILES/UPDATES

CHAPTER 13

Chapter 14

Hardware

In this chapter we will discuss the steps that you should take to ensure that your system is ready to install F-22 ADF/TAW, review the different parts of your system, look at the impact that they can have on performance and consider possible upgrade choices. We will also review the different types of game controllers available and consider the best way of configuring them to ensure that you get the maximum benefit from their use. Finally we will look at the various patch files that are available and list the changes that they introduce.

Part I Getting Started

No doubt you have already installed F-22 ADF or Total Air War by now, but when you start installing or re-installing patch files or supplements to the game you will often find it necessary to start with a fresh install.

Virtual Memory

In most cases, you can leave the operating system to control Virtual Memory as it sees fit, but if you have more than one hard drive you may wish to put the swap file on to a different drive from the one that holds your programs to aid performance. You can achieve this by right clicking on the 'My Computer' icon on the desktop, then selecting Properties, Performance, Virtual Memory. You can now tell the operating system where you want the swap file to be placed. If you change any settings here, you will need to re-boot your PC before they take effect. Unless you are sure that you know what you are doing, do not alter the suggested minimum and maximum sizes that are shown. Remember that virtual memory is limited to the amount of disk space that is available on your system. Depending on the amount of RAM and the type of install that you have, F-22 ADF may require between 50-120MB of free space.

Fragmentation

Before installing any new software it is always a good idea to visit the 'Add/Remove Programs' option in the control panel (Start, Settings, Control Panel). Have a look through the list for software that you do not use any more such as demos and old games. Remove the ones you do not want, but beware that in a lot of cases, saved games and configuration files may remain in the directory where the game was installed, so be prepared to delete those files manually via the 'My Computer' icon on your desktop.

Once the old software has been removed it is time to de-fragment your hard drive (or drives). As you install and delete files on your hard drive, spaces of various sizes will appear between the files. When new files are written they will use the spaces and if the space is not large

enough the files will be split across several areas of the disk, this is called fragmentation. When the file is accessed it will be necessary to read from several places to get the whole file, which is slower then reading the file from a single location. The aim of de-fragmentation is to get all the files on your disk placed so that they are not split, and to ensure that all free space is located in a single area so that new files will not be split when they are written.

Most modern simulations tend to take large amounts of disk space for terrain data, this makes them vulnerable to the perils of fragmentation. You will notice this problem as a slowness, or hesitation when loading new terrain, or delays when starting or ending a simulation as the program creates or removes a swap file. Removing the problem is very simple.

First turn off any screen savers (right-click on the desktop and select Properties) and exit from any programs that are running. Now double click on the 'My Computer' icon then right-click on the drive that you wish to defrag then select Properties, Tools. If you click on 'Defragment Now'. The program will check the status of your drive and advise on the need to defragment the drive. If it states that you have a low level of fragmentation this implies that few files are fragmented, but there may still be significant fragmentation of free space, so if it has been some time since you last defragged your drive it is still worth proceeding. If you have a large drive, it can take several hours to run.

When the process has completed you may install your simulation in the knowledge that all the files will be written to contiguous areas of your hard drive so access to them will be as fast as your system can achieve.

Part II Hardware

The minimum requirements are not likely to cause many problems for most people, as by current standards the need for 16MB of RAM and a P166 processor is not much of a challenge. However, as with most simulations, the reality is that although you could fly with this configuration you will find that faster processors and specialist graphic cards make a huge difference to your enjoyment of the experience.

Processors

The days when we could confidently state that only Intel processors should be used are long gone now, but unfortunately we are still some way from being able to state that any processor will do. If you are already using a Pentium or Pentium II processor then you should not experience any compatibility problems. If however you are using a Cyrix 6x86 processor, there is a risk that the simulation will not identify it correctly and will refuse to run believing, incorrectly, that a non-Pentium class processor is present. There is no easy way around this problem, but it can be fixed by downloading a small program from the Internet, a link to this can be found on the DID web site .

Over-clocking is still very common and many motherboards have made this less painful by placing the bus speed and multiplier settings in the BIOS setup area. This is still not officially recommended and Intel have tried to make it difficult by physically altering some chips to make them un-clockable, but the practice continues. There are many excellent web sites dedicated to the pursuit of speed, and there is little doubt that it is very possible to gain significant performance improvements. However be careful as not all of the components in your system may be able to work at the higher bus speeds that are often involved. In particular be careful when using some older boards with early implementations of Ultra EIDE support as some people have reported hard drive corruption when running at high bus speeds.

The only straight answer to the speed question is 'as fast as you can afford'. However, if you are still using an old 2D graphics card, check out the next section before you consider a faster processor as these days the graphics card can make a sizeable difference to the performance of a simulation.

Graphics cards

There are a huge number of cards available now, with more appearing every month. There is also the added complexity of the choice between AGP and PCI cards in addition to the choice of chipset. When considering graphic cards, the question of software support comes up. Thanks to Microsoft and the provision of DirectX, virtually any current card can be used with any simulation, but as usual some work better than others, and some are directly supported without the need for DirectX. In the case of F22-ADF/ TAW, there is support for 3DFX based cards via Glide, and all other cards via DirectX. At the time this book was published, the only cards that had significant problems were those based on the Power VR chip set and the Nvidia Riva128. These problems were caused by the use of palletised and dynamic textures in ways that caused problems with these cards. Please check the DID website for any progress on this matter, but as the problem is inherent to the design of the software and the specific chipsets, it is unlikely that the problems will have been solved.

Keeping your drivers current helps a lot in reducing problems. It may well be that your card has worked perfectly in the past, but new games can often bring new versions of DirectX that may require updates to your drivers. TAW ships with DirectX 5.2, but other games are currently shipping with DirectX 6, if you install one of these, you will be automatically upgraded to DirectX 6 and some of your drivers will also be changed. In most cases this will be a seamless process and you will not need to do anything else, but if you experience problems after such an upgrade check with your card provider to see if there are any new drivers for your card. As there are many different cards using the same chipset you may find that some are faster than others are when releasing new drivers. In the case of 3DFX based cards it is always worth visiting if your particular supplier is a little slow. The 3DFX site always has the latest reference drivers, which can be used with most 3DFX based cards, but may lack some of the features of the drivers for a specific card.

At present the chipset to beat is the Voodoo 2 from 3DFX (check the patch section regarding this card) but this will change. At present most developers are providing direct support for this card and are ensuring that the texture requirements of their software fit within the texture RAM found on these cards. However, as AGP slots become more prevalent and the price of AGP cards sinks ever lower, the developers are being tempted by the ability of AGP cards to use main RAM to store textures. The means that they are freed from the limitations imposed by the 3DFX cards and can increase the size and number of textures without suffering a huge speed penalty in the process. So if you have not already upgraded your graphics card there will be some

interesting AGP cards to choose from and of course there is always Voodoo 3 to wait for as well.

With some cards the issue of over-clocking has arisen. Many 3D cards have one or more processors on-board and like your main processor, the speed of this chip can directly influence the frame rate. While over-clocking processors is now very common, be careful about doing this with graphic cards. Main processors are generally well cooled, this is not true for the graphic card and over-clocking will translate into high temperatures, which can cause permanent damage to your card. With that warning in mind, check out the screen properties tag for your card, in some cases you will find there is an option to change the clock speed in the advanced options section. 3DFX cards are the most common subject of over-clocking, but the benefits are few and the risks potentially high, so this is not generally advised.

If you are having any problems relating to graphics, first make sure your card is set to its standard clock rate and ensure that your drivers are up to date, then if the problems persist go to the system properties (right-click on 'My Computer', properties) then select Performance, then Graphics. You will see a slider that controls the level of graphics acceleration. Try reducing this a notch or two to see if the problem is eliminated.

If you are not sure which version of DirectX you are running, or if you want to check exactly which drivers you are using, you must locate a program called 'dxinfo'. This is usually located in C:\Program Files\Directx\setup but if you have problems locating it use the 'Find' option from the Start button. When you run this program it will show you the version numbers of all the DirectX drivers which can be helpful when talking to Tech. Support.

Memory

This is another area without a precise answer, but as usual more is generally better. The minimum requirement of 16MB is certainly too low for good performance and even the recommended level of 32MB is less than the program can make use of. However just throwing RAM at your system may be counter productive. Most motherboards have the theoretical ability to hold more RAM than you are ever likely to own, so the real limitation is often the amount of RAM that the motherboard can cache. This is usually not much of a problem either, except if you have a motherboard based on the Intel TX chipset. This chipset is only capable of caching the first 64MB of RAM. If you fit more than this, there may actually be some degradation in performance as the processor will be slow at locating and loading the contents of the RAM that is not cached. When the TX chipset was going through the process of development the price of RAM was high

enough that 64MB probably seemed a reasonable limit, but soon after it was released the price of RAM fell dramatically so the prospect of high RAM levels was not so unlikely. If you are not certain about your chipset, watch your screen during the boot sequence, most computers will display BIOS information that can help you identify the chipset and/or the motherboard manufacturer. The sort of descriptions that you will see will usually include a chipset designation like FX, VX, HX, LX, BX or TX and a number that is usually related to the BIOS version. If you have a TX chipset, do not go beyond 64MB of RAM. This should be fine for F-22 ADF/TAW, but we are already seeing some new simulations that can take advantage of RAM above this level.

If you do decide to add RAM to your PC, be sure that you obtain the correct type as the number of alternatives is getting difficult to keep track of. For more modern systems the standard is the S-DRAM DIMM, which is either suitable for 66Mhz or 100Mhz bus speeds. The faster RAM can be used in slower systems, but not the other way around. Older systems use SIMMs and for the moment they are still easy to obtain, but this may change as the mass market moves to DIMMs. Some motherboards have both SIMM and DIMM slots, be careful when upgrading as not all motherboards allow you to use SIMMs and DIMMs at the same time as they usually run at different voltages. There is no certainty that future motherboards will still use S-DRAM DIMMs as there are many competing 'standards' for the next generation of memory modules. It is however likely that you will get the most life out of 100Mhz S-DRAM DIMMs so if you can use these modules in your motherboard they may be worth paying a small premium for, over 66Mhz DIMMs.

Part III Flight Controllers

There remains a never ending tide of different controllers arriving on the market with every conceivable variation on twisting, turning and programming catered for. The only important consideration here is what works for you, and how the pilot workload can be reduced. The most expensive is not always the best, but often the cheapest options can be disappointing. If you already have a stick that you are happy with try to avoid the advertising that will endeavour to convince you that you will be twice the pilot if you only had their new stick in your hands. Remember it is you flying the plane not the stick. That said, if you are managing to get a good performance flying with a non-programmable stick using the keyboard for the throttle, it is likely that you will do better with a modest upgrade to your equipment. The military concept of HOTAS (Hands On Throttle And Stick) is a good one. If you can fly and fight without taking your hands off the primary flight controls you are more likely to remain in control.

Remember that your stick must be set-up and calibrated in Windows before you attempt to use it in the simulation. A lot of joystick problems can be traced to mistakes in this area. Use, Start, Settings, Control Panel, Game Controllers to perform these functions.

Programmable Joysticks

There are many sources for these controls now, in addition to the old standards of Thrustmaster and CH there are excellent offerings from Saitek and others now on the market. Most of these sticks have relatively simple programming systems that should not present any problems, and the more popular sticks are usually supported with files on the game CD's, or by their own Web sites. The golden rule when laying out the controls is to keep it simple and as far as possible standard. Most flight simulations by their nature have similar control requirements for the basic functions. The main stick and throttle controls rarely vary (except for helicopters) and all will have the need to cycle between weapons, select targets, adjust radar modes etc. If you can layout these controls in the same way for each simulation that you fly, it will be much easier for you to switch between them. Clearly the

actual keys that activate the functions will differ between the simulations, but the advantage of programmable controls is that the different keys can still be assigned to the same button on your joystick.

When selecting which controls to map on to your stick, have a thought to the basic needs of 'Flight and Fight'. You should be able to navigate between waypoints scanning for the enemy and engaging when necessary without taking your eyes off the screen. What you do not need is the ability to raise or lower under-carriage or open the canopy. Quickly switching to the padlock view can be a life saver, but hit the fly-by view by mistake and you will probably get shot down. The more controls that you have on the sticks, the more chance there is of hitting the wrong one. Modern controls give you the ability to change the function of a button depending on the state of other buttons. The only time that this is recommended is when you wish to vary the direction of a function, say to cycle padlock forward or backwards, or when you wish to have a button perform the same function, but use a different keyboard key, as in the case of weapon selection in Air to Air mode and Air to Ground mode.

Throttles

Some throttles are dedicated to particular sticks, like the Thrustmaster TQS, others like those from CH can be used with many different sticks and in some cases can allow non-programmable sticks to be programmed as well. When selecting a throttle, after checking for compatibility with your stick, ensure that you like the way that the throttle is adjusted. Some move in an arc around a pivoting point, others slide backwards and forwards. Both methods work, but some people may prefer one over the other.

Rudders

In fast jet simulations, rudders are seldom of much use except for controlling the nose wheel when on the ground. If you like flying helicopter simulations they are often vital, but if not then consider using the keyboard or if you really must, map them onto a hat switch. Some sticks provide rudder control through a twisting action on the joystick. This works, but can make control inputs difficult when you try to control the direction of flight at the same time as using the rudders, rarely a problem in fast jets, but not recommended for helicopters. A better solution is that offered by Saitek who have placed a large rocker switch on the throttle, which acts as a rudder control.

Keyboard Replacements.

There are now several devices that present a flat surface with soft keys beneath it that can be programmed to replace keyboard keys. The

Saitek Dash is a good example of this. If you are careful, these devices can entirely replace the keyboard while flying, and generally take up less space. Some of them take the keyboard commands from pre-set chips that hold the commands for many different simulations, others like the Dash as fully programmable. If you use such a device, follow the same rules as for the sticks, keep it simple. Critical functions should be on the stick, not here, but you may find it useful to have functions that are only accessible by pressing shift keys presented as single key presses.

Part IV Patch Files/Updates

Patch Files/Updates

As with most sims these days, F22-ADF/TAW was not completely perfect when released. Various patch files have been made available on the Internet and magazine cover disks. These files do not just correct problems, they also change or add some features to the sim, so even if you are not having problems you should review this section.

Patch Versions

There are different versions of most patches depending on the language version of F-22 ADF/TAW that you have. Also, be aware that if you have an OEM version of F-22 ADF, usually supplied with a motherboard or a new system, certain patch files will not work.

F-22 ADF V5.144 Patch

This patch is the main update for the sim and if obtained from the DID Internet site , the correct patch for your system will be selected for you, if you get it elsewhere please ensure that you have the correct language and graphics format (Direct3D or Glide) version.

Patch Details

This information has been provided by DID and accompanies the patch file Video Card Users Users of the nVidia Riva 128 who replace this device with another video card will have to remove or rename the 'nvidriva.128' file which is present in the 'DID\F22ADF\program' directory (or wherever F-22 ADF was installed to). If this file is not removed then visual anomalies may be present when running F-22 ADF on the new video card.

Notes for Users with Voodoo II Chipset Based Video Cards The problem which prevented the 3Dfx\Glide version of F-22 ADF working with Voodoo II chipset cards has now been fixed in this version.

Notes for Users with Permedia II Chipset Based Video Cards There has been a problem reported with Permedia II chipset cards during the testing of this version. If, while flying the plane, you enter into the options menu (shift + 'O') and return to the main game you will experience graphical anomalies. To prevent the problem we recommend that the options menu screen only be accessed from the main menu.

The following bugs have been fixed within F-22 ADF:

- The LANTIRN zoom problems when LANTIRN is slaved have been fixed
- The problem caused by requesting refuel twice has been fixed
- The inter-plane collision on the ground has been fixed. Planes would not collide if the player was moving very slowly
- The vocal warnings cockpit switch to turn off Bitchin' Betty from the Systems MFD has been fixed
- Wingmen now ignore formation commands when they're on the ground
- View padlock no longer padlocks onto player's plane
- The lock-up when exiting the game while ACMI is still recording has been fixed
- The crash which would happen sometimes upon selecting LANTIRN has been fixed
- The crash to do with having a static target in your shoot list and looking down at the right-hand MFD has been fixed (thanks to Ray Viper Purvis for letting us know about that one)
- The crash caused by pressing Z after ejecting has been fixed

F-22 ADF Multi-player and Communications Please note that the patched version of F-22 ADF will not communicate with the original release. The following changes have been made to the multi-player section of the game:

- Improved multi-play connectivity using TCP/IP and IPX over services such as KALI95
- Improved plane position prediction to reduce warping
- The bug that occurs when the server cancels the DirectPlay dialog box which causes the selected service provider not to reset correctly has now been fixed. It now resets the selected service and screen correctly
- The client's (game joiner's) multi-player details screen now resets each time a new scenario is selected. It displays the correct number of team buttons and weapons list

- The amount of data being sent across all media has now been reduced. This prevents high specification machines swamping lower specification machines with data

Connectivity Instructions for each DirectPlay Service Provider Follow the instructions provided below that are appropriate to your connection method:

IPX

Select IPX Connection For DirectPlay

Host:

Select new game button Wait for the others to join

Joiner:

Select the game from the 'Games in Progress' list
Select the join game button

TCP/IP

Select TCP/IP Connection For DirectPlay

Host:

Select new game button Wait for the others to join

Joiner:

Select join game button, a window will appear
Enter the IP address or the DNS of the host machine
Select the game from the 'Games in Progress' list
Select the join game button

Modem

Select Modem Connection For DirectPlay

Host:

Select new game button
Select the correct modem from the list in the dialog box
Click the 'Answer' button in the dialog box
Wait for the other player to join

Joiner:

Select the join game button
Enter the telephone number of the host machine
Select the correct modem from the list in the dialog box
Click the 'Connect' button in the dialog box
Select the game from the 'Games in Progress' list
Select the join game button

Serial

Select Serial Connection For DirectPlay

Make sure that the settings in the Serial Connection dialog box are the same for both machines (except port number). (e.g. Baud Rate: 57600, Stop Bits: 1 bit, Parity: No Parity, Flow: RTS/DTR)

Host:

Select the new game button
Complete the settings dialog box
Wait for the other player to join

Joiner:

Select the join game button
Complete the settings dialog box
Select the game from the 'Games in Progress' list
Select the join game button

Graphics Cards Issues

The following graphics cards are supported by Direct 3D in addition to the cards supported in the initial F-22 ADF release. Please note that graphical anomalies may periodically occur on some of these products due to driver and hardware problems.

- Cards based around the Permedia and Permedia II chipsets Cards based around Nvidia Riva with PCI bus (this previously only worked with AGP)
- Cards based around the ATI Rage Pro with PCI bus (this previously only worked with AGP)
- Cards based around the Rendition V2200 chipset

In addition problems have been found on the following cards:

- Serious graphical anomalies on Power VR chipset based machines when using Direct 3D
- Problems have been found in test with Power VR or Rendition chipset cards involving the fogging effects

What's New?

There are many game play enhancements that have been included in his upgrade which make F-22 ADF more enjoyable to play. The following enhancements have been made:

- There is now a realistic fire delay between SAMs locking on and firing at you. They previously launched instantaneously
- The sensor range is no longer changed when you switch to manual Emcon levels

- SMART PILOTS controlled aircraft now have a realistic number of cannon rounds as found in the actual aircraft
- A systems display for wingmen has been added to allow you to view their weapons and fuel status. Click the WS button in the system display to cycle through each of the wingmen
- The wingmen and wing-leader damage status can now be seen at a glance on the systems display. Status is shown by the color of the wingman text. White is fully functional, yellow is damaged and red usually means imminent use of the Ejector seat. If any of the pilots in your flight are shot down then they will be removed from your systems display
- The shoot list generation and target prioritization's have been improved. The system will now prioritize targets in center of HUD higher than the other potential threats. To prioritize something higher, place it in the center of the HUD, and press T
- Cluster bombs have been adjusted so that they deploy when they reach a certain altitude. They used to deploy bomblets after a given time making it impossible to use them at low-level effectively
- There has been a blast radius added to the bombs. Bombs will now damage ground vehicles and planes in close proximity, not just those hit (don't drop a bomb too low now!)
- The 'zoom-out' in Satellite view has been increased
- The damage modeling has been adjusted. Cannon rounds now do much less damage to buildings, as do MK20s
- The manual adjustment of auto-pilot values in the Auto-pilot display has been adjusted to speed up the rate of change of the values
- The weapon selection system has been modified. Previously when last AIM120 was released Cannon would be selected. Now, AIM9Xs are selected if present
- The padlock views can no longer be used to padlock planes outside of visual range. You can still use target padlock though, since your Helmet Mounted Display avionics are showing you the location of the target
- A range value has added to the superimposed MFD displays in full screen HUD
- The missile damage for AIM9Xs and AIM120s has been adjusted
- The Radar guided missiles and SAMs are now slightly easier to spoof in medium and hard difficulty levels
- A wider selection of HUD colors has now been added. The HUD color is now saved between game loads

- A vertical speed indicator value has now been added to ILS HUD. (VSI – in feet per second)
- The plane damage code has been adjusted – planes won't disintegrate quite as often, and the player's MFDs won't all get knocked out together
- Cluster Airfield – The target view in the briefing now shows a picture of the hangar which must be destroyed instead of the control tower. Finding the hangar used to be trial and error
- Current wide angle views are now saved when you exit the game
- If the airbrake is damaged, wheel brakes still work
- The difficulty has been adjusted in following missions: CAP UK, Raid Egypt and Cluster CAS
- Alt C (joystick center) settings are now saved when you exit the game
- You don't need to kill the throttle completely now to detach from the refueler
- The aspect marker in HUD has been adjusted so it works correctly when tracking a target over the shoulder
- The throttle noise is now louder when afterburner engaged
- A new speech quality option has been added to the options screen
- Changed expansion strip thumping noise so that it only occurs on taxiways – not on runways
- Missile trails can now be seen at a greater distance

F-22 ADF Intel 3DFX Patch

This is the only patch that will work on the OEM version supplied with Intel motherboards. The patch fixes various problems with Voodoo 1 and Voodoo 2 graphic cards.

F-22 ADF Multiplayer Patch

This patch should be installed after the V5.144 patch and cannot be used in addition to the Union Reality patch.

Patch Details

This information has been provided by DID and accompanies the patch file :

This patch is issued to fix the following multiplay bugs:
Players timing out when trying to join a game
Plane warping

Inconsistency in remote object position
Red team only can re-arm when landing at base
Removed fatal error "It's like a jungle sometimes ..."

If you want to limit the amount of packets sent per second, put the word KALI on the command line if you are running from a shortcut.

F-22 ADF Union Reality Patch

This patch adds support for the Union Reality headset and allows you to pan the cockpit view just by moving your head. This view can be toggled on and off to avoid unintended movement.

TAW Patch

At the time this book was published there had been only one patch for TAW and the following information regarding the patch was provided by DID:

Patch Details

Taxi bug when your flight number > 255. This should fix the problem of taxiing not working later in a campaign.

Removal of 'Noise con 5 message' when getting ready to taxi.

No need to tell wingmen to 'push one'.

Fixed AWACS skip-it bug. With this error the Awacs would pass you an intercept, then when you are in vis-ident range of the target tell you to skip it.

Removed player helicopter supply missions.

Removed player to plane collision on the ground (not in the air).

Fixed engine spool up sounds.

Added union reality patch. If you don't have union reality

hardware, then don't worry about it.

Can now drop tanks in ENCOM 1.

Added help message when trying to send messages in ENCOM 1.

Cannot say 'yes' 'no' in ENCOM 1.

Can now skip while under threat on the ground.

Fixed wingmen range to fire bug. Wingmen sometimes released weapons while out of range.

Fixed autopilot no fuel bug. When you run out of fuel you can engage the autopilot, this turns the engines back on even though you're out of fuel.

GAME.CFG flags

Putting the following in your game.cfg will enable these options:

START_ON_RUNWAY = 1

This will put the players flight on the runway at the start of any campaign mission (just like a scramble mission). The player can then just takeoff and start the mission. You don't need to wait for any messages from the tower.

OTHER_FLIGHTS_IN_AIR = 1

This will put you in the world when the other flights in your mission have taken off. If you set the above flag also you will be able to get your mission underway very quickly.

REARM_WINGMEN = 1

This means that when you land and rearm you wingmen will also be rearmed. This will happen even if your wingmen are in the air.

LAND_AT_ANY_BASE = 1

This means that you will get a mission success for landing at any allied airbase. The completion events will still state your real home base however.

Glossary

AA or A Air —To-Air.

AAA — Or 'Triple A'Anti Aircraft Artillery.

AAM — Air-to-Air Missile.

AA-10 — AlamoNATO designation for the R-27.

AA-11 — ArcherNATO designation for the R-73 IR missile.

AA-12 — Adder NATO designation for the R-77 IR missile.

AAR — Air-to-Air Refueling.

AAV — Armored Amphibious Assault Vehicle.

AB — AfterBurner.

AC — Aircraft.

ACA — Agile Combat Aircraft.

ACE — Armored Combat Earth mover.

AC-GEN — Aircraft generator.

ACM — Air Combat Maneuvers.

ACRV — Armored Command and Reconnaissance Vehicle.

AD — Air Defense.

ADAM — Area Denial Artillery Munitions.

ADATS — Air Defense Anti-Tank System.

ADI — Attitude Director Indicator.

AEW — Airborne Early Warning.

AEV — Armored Engineer Vehicle.

Afterburner — Part of a jet engine that increases the power of the engine by burning fuel in the jet exhaust.

AG or A-G — Air-to-Ground.

AGM — Air-to-Ground Missile.

Aileron — Control surface on an aircraft wing that produces aircraft roll.

AIM — Air Intercept Missile.

AIR-BRK — Air Brake.

AIR-FRM — The Air Frame.

All-Aspect — Weapons that are effective at any angle to the target.

ALT — Altitude above sea level.

AMRAAM — Advanced Medium Range Air-to-Air Missile.

AOA — Angle of Attack.

AP — Armor Piercing.

Approach — Line-up prior to landing.

APC — Armored Personnel Carrier.

APHE — Armor-Piercing High Explosive.

ARM — Anti-Radiation Missile.

ARMY — Military Target

ASARS — Advanced Synthetic Aperture Radar System.

Aspect Angle — The angle formed between the line of sight and the nose of the target aircraft.

ASW — Anti-Submarine Warfare.

ASRAAM — Advanced Short Range Air-to-Air Missile.

Attitude — The state of an aircraft in terms of pitch, bank and yaw.

ATC — Air Traffic Control.

ATF — Advanced Tactical Fighter.

ATGW — Anti Tank Guided Weapon.

ATM — Air Tasking Message.

ATO — Air Tasking Order

Auto-pilot — A mode in which the flight control computer takes control of the aircraft.

AUX-POW — Auxiliary Power.

AVI — Avionics.

Avionics — Electronic systems in the aircraft.

AWACS — Airborne Warning And Control System.

BAI — Battlefield Air Interdiction.

Bandit — A known hostile aircraft.

Bank — The angle of the wings about the longitudinal axis referenced to the horizontal.

Bank — To roll the aircraft to one side and induce a turn.

BCOM — Base Commander.

Beaming — Flying perpendicular to the emissions from a threat radar.

BDA — Bomb Damage Assessment.

BFM — Basic Fighter Maneuvers.

Bingo — 'Bingo Fuel' is the amount needed to return to base.

Blackout — Loss of consciousness due to excessive forces on the pilot.

Blast-Fragmentation Warhead
An explosive charge which creates a large amount of shrapnel.

BLU — Bomb Live Unit.

BMEWS — Ballistic Missile Early Warning System.

Bogey — An unknown aircraft. A Bogey becomes a bandit when identified as hostile.

Bracket — An ACM tactic in which two (or more) aircraft fly opposite sides of a threat formation.

Break — To suddenly turn in the hope that an enemy following will lose his tactical advantage.

Break-Through Pressure — Pressure needed to overcome the G-limiter on the joystick.

Bug-Out — Leave a dogfight.

BVR — Beyond Visual Range.

C4 — Command, Communications, Control & Computing Target.

Callsign — A pilot's or controller's code name.

CAP — Combat Air Patrol.

CAS — Close Air Support.

CBU — Cluster-Bomb Unit.

CEP — Circular Error Probability (measure of bombing performance).

CFPD — Command Flight Path Display System.

Chaff — Packets of foil used to decoy or obscure radar systems.

COMMS — The F-22's Communication Systems.

Compass Tape — Heading indicator at the top of the HUD.

Concussive — With violent, if not explosive, force.

Corner Velocity — The velocity at which an aircraft achieves its best turn performance.

Continuous Wave Radar — A system which emits radio waves continuously, as opposed to pulses (see PULSE DOPPLER RADAR).

Court Martial — A military trial held when breaches of conduct codes occur.

CTOL — Conventional Take-Off and Landing.

CS — Control Surfaces.

DEF — Defensive Target.

DEFCON — DEFense CONdition. A series of alert conditions set which cause world wide forces to establish escalating levels of readiness and security.

DLIR — Downward Looking InfraRed.

Dogfight — Engaging enemy aircraft.

Doppler Radar — Airborne radar which makes use of Doppler effect (frequency shift) in signals reflected from ahead and behind aircraft to give measure of speed over the ground and to distinguish moving targets.

Drogue Chute — A parachute released to slow an aircraft, usually when landing.

Drag Factor — A number which indicates how un-aerodynamic external stores on an aircraft are.

Durandal — Runway cratering missile.

ECCM — Electronic Counter Counter Measures.

ECM — Electronic Counter Measures.

Element — Two aircraft working together as a team, possibly as an element of a larger flight.

Elevators — Aircraft control surfaces, located at the back of the horizontal stabilizers, which provide pitching movement.

EO — Electro-Optical.

EMCON — EMission CONtrol Level.

ENG — Engine.

ERA — Explosive Reactive Armor.

ESM — Electronic Support Measures.

EW — Electronic Warfare.

EW Radar — Early Warning Radar.

FAB — Fugasnaya Aviatsyonna Bomba, Russian designation for 'general purpose bomb'.

FAC — Forward Air Controller.

FARP — Forward Air Refueling Point.

FBW — Fly-by-wire a flight control system which transmits flight commands via wires to servo actuators which drive the ailerons, rudders or other control surfaces. In most FBW systems, pilot input is processed and possibly negated by a flight computer before being sent to the control actuators.

FCC — Fire Command Center.

FCS — Fire Control System.

FCS — Flight Control System.

FEBA — Forward Edge of Battle Area.

Fire and forget — A missile that once fired, will guide itself to its target.

Flak — Shrapnel produced by AAA shells exploding.

Flame-out — Stalling of aircraft engine due to adverse circumstances; e.g. bird-strike, damge.

Flaps — Control surfaces on aircraft wings which increase lift for a given flight condition and allow a lower airspeed than is normal in flight.

Flaperons — A useful control surface which is a cross between ailerons and flaps.

Flares — Pyrotechnic packages which burn with intense heat designed to confuse InfraRed missiles.

Flashpoint — A trouble zone, be it economic, military or otherwise.

FLIR — Forward Looking InfraRed

FOD — Foreign Object Damage

Fuze — An adjustable triggering device in a missile, bomb or other weapon

G, G Force — A force acting upon the aircraft and pilot when maneuvering, expressed in terms of the earth's gravitational force.

GB — Ground Based Target.

GBU — Guided Bomb Unit.

GLCM — Ground Launched Cruise Missile.

GLLD — Ground Laser Locator Designator.

G-LOC — G-induced Loss Of Consciousness.

GPS — Global Positioning System.

G-suit — A suit worn by pilots which reduces the effects of high G forces.

HARM — High-speed Anti-Radiation Missile.

Hard target — Target which is armored.

Hard points — Weapons pylons for carrying anything except fuel (see WET POINTS).

HAS — Hardened Aircraft Shelter.

HE — High Explosive.

HEAT — High Explosive Anti-Tank.

HE-FRAG — High Explosive Fragmentation

HOTAS — Hands On Throttle And Stick, which puts all controls at the pilot's finger tips.

HSI — Horizontal Situation Indicator - a cockpit indicator which combines a compass with information from an inertial reference system or navigation beacons to indicate the relationship of the aircraft with the planned course.

HUD — Head-Up Display.

HYD — Hydraulic systems.

IFDL — In Flight Data Link

IFF — Identification Friend or Foe.

IIR — Imaging InfraRed.

ILS — Instrument Landing System.

IND — Industrial Target.

INF — Infrastructure Target.

Indicated airspeed — The airspeed shown by an air-speed indicator and not corrected for error due to air density variations, caused by altitude and temperature.

INS — Inertial Navigation System.

IR — Infra-Red.

IRI — Intermittent Radar Imaging.

IRD — InfraRed Decoy.

IRSTS — Infrared Search and Track. A system that tracks aircraft and missiles using the heat generated by their engines and by their friction with the air.

Jamming — Confusing the enemy radar by using high-energy bursts of a certain frequency.

JDAM — Joint Direct Attack Munitions.

JSOW — Joint Stand Off Weapon.

J-STARS — Joint Surveillance Targeting And Reconnaissance System

JTACMS — Joint Tactical Missile System.

JTIDS — Joint Tactical Information Distribution System.

KC -135 — Mid-air refueling tanker.

KIA — Killed In Action.

Knock it off — Slang for 'end the mission'.

KNOTS — Nautical miles per hour.

KTAS — Knots True Air Speed.

KIAS — Knots Indicated Air Speed.

KTS — Abbreviation for Knots.

LANTIRN — Low Altitude Navigation and Targeting Infra- red Attack System for Night.

LGB — Laser Guided Bomb.

Lizard — A term often used to describe the enemy leader.

Load factor — The force acting on an aircraft as a multiple of the force of gravity.

Lock — Acquire a target and fix weapons aiming systems on it.

Loose cannon — A renegade pilot.

LRMTS — Laser Ranger and Marked Target Seeker.

LZ — Landing Zone.

MACH — Unit of speed equal to the speed of sound at your altitude.

MAS — Maneuvering Attack System.

MAW — Missile Approach Warning

MBT — Main Battle Tank.

MEWS — Mobile Electronic Warfare System.

MFD — Multi-Function Display unit.

MIA — Missing In Action.

MiG — Mikoyan Gurevich - the founders of one of major Russian aircraft design bureaus.

MMD — Moving map display used for navigation.

MMS — Missile Management System.

MP — Maritime Patrol.

MRM — Medium Range Missile.

NATO — North Atlantic Treaty Organization.

NAV — Naval Target.

NM — Nautical mile - 6,076 feet.

NAV — Navigation.

NBC — Nuclear, Biological, Chemical.

Negative G's — G-force that forces you out of your seat.

NOE — Nap Of the Earth, very low altitude.

NVE/NV — Night Vision Equipment.

NWS — Nose Wheel Steering.

Ordnance — Bombs, missiles, bullets and other offensive hardware.

OS — Offensive Support.

OTR — Operational Turn-Round. Rapid re-arming and refuelling of combat aircraft.

OTH-B — Over the Horizon Backscatter (radar).

Padlock — Directs the pilot's view to a selected object.

PAVE TACK — Targeting system for laser guided bombs

PGB — Precision Guided Bomb.

Pincer — As Bracket maneuver.

PIO — Pilot Induced Oscillation - oscillation in an aircraft's flight path or attitude caused by a pilot failing to compensate for the lag time between pilot input andaircraft reaction.

Pipper — A small dot at the centre of the aiming reticule.

PIT — Political Target .

Pitch — The angle of an aircraft's nose above or below the horizon.

Pitch ladder — Pitch indicator in the HUD.

PK — Probability of Kill.

POL — Petrol, Oil & Lubricant Target.

Positive G's — G-force that forces you into your seat.

Predictor sight — A computerized gun sight that predicts the flight of cannon shells.

PRES — Cockpit Pressure.

Pressure breathing — Forced breathing to help cope with high G Maneuvers.

Pulse doppler radar — Radar that emits short bursts of radio waves and detects objects by the returning echo.

Push 1 — (Also known as STUD) Frequency setting on aircraft radio (similar to presets in a car radio).

Radar — Radio Detection And Ranging.

RCS — Radar Cross Section

Recce — Reconnaissance.

Redout — Effect felt by pilot when pushing negative G's for too long.

RHWR — Radar Homing Warning Receiver.

RHAW — Radar Homing and Warning.

RI — Radar Imaging

RMG — Ranging Machine Gun.

ROE — Rules Of Engagement - rules governing the conditions under which a fighter can engage or fire upon an enemy.

Roll — Rotation around an aircraft's longitudinal axis.

Rookie — Inexperienced pilot.

RP — Rocket Propelled.

RPM — Revolutions Per Minute.

RSBN — A radio navigation beacon.

RTB — Return To Base.

Rudder — Control surface on the tail of an aircraft which affects the yaw of aircraft.

RV — Rendezvous.

RWR — Radar Warning Receiver.

R-27 — An advanced Russian AA radar-guided missile.

R-60 — A second-generation Russian heat-seeking missile.

R-73 — A third-generation Russian heat-seeking missile.

SA — Strike/Attack.

SA — Semi-Active. Refers to radar guided missile which requires the radar to illuminate the target all the way to the impact.

SA — Situational Awareness, the amount of awareness a pilot has about the local tactical environment.

Sandwich maneuver — (Also drag maneuver) Decoy maneuver to distract fighters away from their targets.

SAMs — Surface-to-Air Missiles.

SAR — Search and Rescue.

SARH — Semi-Active Radar Homing.

SEAD — Suppression of Enemy Air Defenses.

Semi-active — Used to describe a missile which must be guided until its own radar can take over.

Sideslip — Motion of an aircraft to the right or left perpendicular to its longitudinal axis.

Six o'clock — Directly behind an aircraft, where it is most vulnerable.

SLAM — Stand-off Land Attack Missile.

SLAR — Side-Looking Airborne Radar.

Slats — Extendible leading edge high lift devices.

SLIR — Sideways-Looking InfraRed (system).

Soft target — Target without any armor.

SRAM — Short Range Attack Missile.

STALL — Loss of control due to low airspeed or excessive Maneuvers at high altitude.

Statute mile — 5,280 feet..

Stealth — Ability to avoid detection.

TADS — Target Acquisition and Designator System.

TCOM — Theater Commander

TERPROM — Terrain following system.

Terrain hugging — Flying at 500 feet or below, following the contours of the land.

TFR — Terrain Following Radar.

Threat — Any enemy in your vicinity.

Thrust — Power produced by your engines, usually referred to as a percentage.

Thrust vectoring — The ability to adjust the direction of thrust via movable nozzles.

TOT — Time On Target

TOW — Time On Waypoint

TRIM — Setting aircraft controls or trim devices so that the aircraft maintains a desired attitude.

Trim tab — A small control surface attached to an aileron of other larger control surface for the purpose of making small trim corrections to that surface's position.

True airspeed — The actual speed at which the aircraft is travelling through the surrounding atmosphere.

TWS — Track While Scan radar mode.

UND — Under carriage.

VASI — Visual Approach Slope Indicator system of lights for landing assistance.

Velocity vector — An indicator in the HUD which shows predicted path of travel.

Vertical velocity — The sink or climb rate of an aircraft.

Virtual cockpit — True 3-D scrolling, panning cockpit.

VSI — Vertical Speed Indicator.

V/STOL — Vertical/Short Take-Off and Landing.

W-BAY — Weapons Bay.

Waypoint — A position in the world to which you have to fly.

WCS — Weapon Control System.

Wet points — Places on the plane where external fuel tanks can be mounted.

Wild weasel — Anti SAM RADAR mission, specifically against enemy air defenses.

Wingman — A flying partner.

Wire — The correct flight path for weapon delivery.

WP — WayPoint.

WW — Wild Weasel

Yaw — Rotation of aircraft about its vertical axis.

YGTBSM — 'You got to be shitting me'.

Zero-zero ejection — Ejection at zero altitude and zero speed.

THE OFFICIAL F-22 ADF
Strategy Guide

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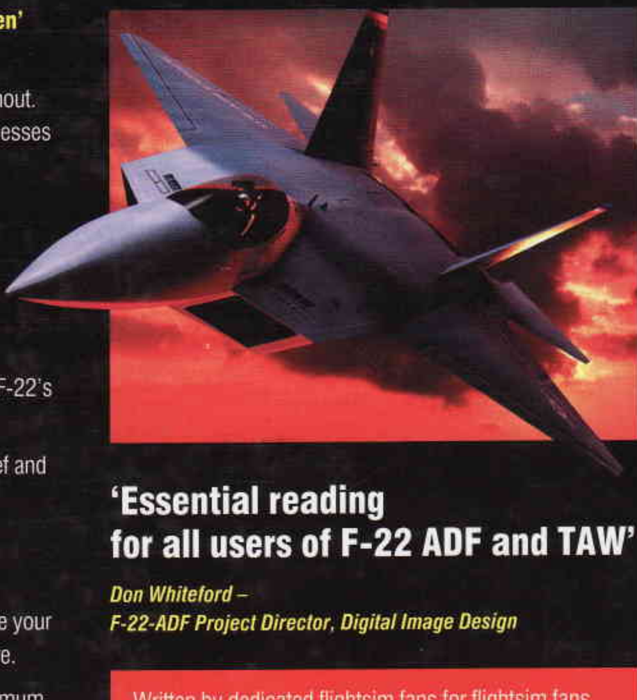

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Don Whiteford –
F-22-ADF Project Director, Digital Image Design

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